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475

Chemical Notes.

Being the Substance of a Course of
Lectures delivered by
Thomas Cooper M. D.
in Philad.a during the Spring of 1817.

Taken by Hugh L. Hodge.

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Lectures on Chymistry by Judge Cooper.

Chemical Affinity.

I have finished those preliminary observations, which I conceived were necessary, that you might understand the Phraseology, to be employed in the ensuing lectures. I shall now enter more directly into our subject, & endeavour to point out the peculiarities of Chemical Affinity, as distinguished from all other attractions. It is evident that all bodies are made up of particles & are divisible into those particles by mechanical means: thus sugar can be ground into a fine powder — meal can be bolted & rendered in this manner still finer —

The force which held together the particles of sugar, before any means was employed to seperate them was the power which attracted these particles together. What is the cause of this attraction we have no power to ascertain - but we can only express the phenomena which we observe. All matter is attracted to all matter - all the planets are attracted to the Sun & the Sun to all ~~matter~~ the planets. Small masses obey the larger - on this account as the sun is the largest mass, the planets revolve around it. So also are the attractions of electricity & magnetism; the forces we observe but the cause we cannot explain. There is another power possessed by matter viz. Repulsion; so that the attraction of bodies is confined to certain distances & cannot reach beyond these. The particles of a body are not in absolute contact, as they can be

removed farther from each other by heat, & be brought nearer by cold. A piece of wire, when heated will expand in every direction, & the flu in a thermometer tube will occupy a greater s[pace] space according to the intensity of the heat. The same appears in large masses of matter, as the planets altho' attracted by the Sun, are at the same time repelled, so that they cannot approach cl[ose]ser. I mention these attractions altho' not bearing directly on the subject as there is no chance of confounding them with chemical affinity: but they are all of a similar nature, whether however depending on one cause or on many is not known. Chemical affinity is most apt to be confounded with the attraction of cohesion by which attract[ion] all the particles of a

body are united together so as to form one whole. It is by this that a mountain is formed out of numerous particles. & that a stone is rendered a compact mass of matter. To ignorant persons & to those who are unacquainted with scientific studies this is the only attraction which is known, as it is the only one which comes under the cognizance of their senses. It will therefore be necessary for me to show how chemical affy differs from the attraction of cohesion. Attraction of aggregation or cohesion is that by which any particles adhere together so as to form one mass: this varies as to hardness. It may be very hard - as the diamond - less hard as metals - earths &c. — it may be soft as muscle - lard &c &c — — liquid - as water oils &c & vaporous or aeriform - as gases

to the various airs or gases. How far these various states ~~will~~ are dependant on latent heat, or electricity or quantity of surface opposed is not yet known: perhaps they will be found depending chiefly on latent heat. This attraction operates on the integrant particles of a body only & not on its constituent or ultimate particles. Thus iron when filed ground & washed, will be divided into particles which are very minute, but the particle is unaltered as to its nature, it is still iron. Hence altho' the force of cohesion is overcome, each particle remains similar to the original compound or ratter mass. So, also when cohesion is overcome not by mechanical force - but by heat - as in the melting of metals or in the sublimation of sulphur - by going to it will be found, that the melted or sublimed

portions do not differ from the original substance. This is attraction of cohesion as it occurs among particles of the same mass - but it also takes place between particles of different masses. This is increased by pressure - & by augmenting the size of the tangible surface. To show that it depends as to force on the surface approximated, take 2 bullets - press them together & they will not adhere as they being spheres touch each other in one point only. So also if they are rough - the difficulty is increased - pair off a portion of the surface & separate them smooth - & they will adhere with considerable force - so also - a piece of leather - (the sucker of the school boy) when laid dry on a stone will not adhere as touching only in a few points if it be made wet - then touching in many points it will lift a considerable weight. In like manner two pieces of smooth marble placed

on each other will adhere closely. Attraction of cohesion depends on the mechanical contact of surfaces; & its force or power can be measured. You can ascertain the force by which the leather adhered to the stone or the two pieces of marble to each other, by discovering how great a weight would seperate them. Here the weight is the exponent of the power. This has been turned to a useful purpose in Europe. it was a great desideratum to determine the force of cohesion in different metallic wires. To find out, several wires of different metals were employed - care being taken that they were all of the same diameter - weights were attached to these - & those weights which were just sufficient to break them were the exponents of the attraction of cohesion which existed. There is an electrical experiment which has

a bearing on this subject. When a spark of the electric fluid passes along a wire - it is not visible - if however it passes along a chain, the links of which are in apparent contact. the spark will be visible at every link passing from one to the other - If a weight be attached to the chain so as to bring the links into closer contact - no spark will be visible. This shows that bodies are not in actual contact - even when they appear to be in this condition This is exemplified not only by electricity but by heat also - as it is a common property of all bodies to expand by heat. therefore the particles can be separated to a greater distance when heat is applied than before - altho' this is not apparent to the senses We also see, that a carpenter wishing to glue two pieces of wood together - planes them smooth as the smoother they are - the greater will be the

number of tangible points. From what has been said it appears, that the attraction of cohesion by which small particles are connected so as to form a larger body, is characterized 1st by its operating on the integrant particles of a body only, which were originally separate & causing them to cohere. 2nd by its operating at distances, which in many instances are apparent. 3rd " by its forming a simple mass out of numerous particles - 4th by the particles remaining of a similar nature to the mass which is formed by their union 5th " by the circumstance that its force can be estimated by figures - as the weight necessary to separate the sucker from the stone. 6th by the circumstance that it can be overcome by mechanical means - it can however be overcome by heat which removes the particles to a greater dis-

x if a compound

-tance from each other - & by Chemical affinity
These are the characteristics of the attⁿ of cohesion
but it is now necessary to show the points of diff-
ference between it & chemical attracⁿ
Chemical Attracⁿ called also attⁿ of composition
& chemical affinity. This last was employed meta-
phorically - as if there were some affinity existing or
some choice made. It differs from the other
in the following particulars. 1st - Cohesion always
unites small bodies into larger - chemical affinity
disunites in the first place - & separates all bodies
into their minutest parts. 2nd It does not act
on the integrant - but on the ultimate particles
of a body - take for example a grain of comⁿ salt
now by grinding - sifting - &c this we may suppose
can be divided into a million parts: still how-
ever each of these, is a particle of salt - having all

No water, except ac-
cidental.

the properties of salt. If one of these par-
ticles be subjected to chemical analysis, it will be
ascertained to consist of 3 substances, soda, mu-
riatic acid - & water. Moreover each of these will
prove to consist of 2 others viz. soda - of a
metalloid - & air: muriatic acid - of a gas
& a base: & water of 2 gases. No mechanical
trituration can do this - no force can show
what composes a body; it is chemistry which
divides bodies into these constituent ultimate par-
ticles. Lime Stone - consists of lime, air - &
water - The water consists - of hydrogen & oxy-
gen: - the air - of charcoal & oxygen: - the lime
of a metalloid - & oxygen: the result of the union
of these is a ~~mixture~~ substance having properties
different from any of the ingredients.

3rd Chemical affinity operates at distances
which can in no instance be measured & there

is no sensible motion. 4th Chemical Affinity is a much more complex process. 5th From dissimilar particles there results a compound different from any of the original particles. 6th The force of this attraction can only be expressed by conjecture 7th It cannot be destroyed by any force. 8th It destroys the attract. of cohesion & resists all other attracts. indeed so different are these two attractions, that they are in an inverse ratio to each other—r

Many Definitions have been given of Chymistry. those of Black, of Thomson, of Fourcroy & of many others are, to my mind, incorrect. I have met with none to satisfy me: we want a neat, clear, & decided definition. The cause of this difficulty may be seen by considering what a Chemist has to do— After a mass is

seperated mechanically into minute parts - Analy-
-sis discovers their last elements & hence those ar-
-ticles which no grinding filing sifting or bolting
could arrive at - are procured by chemical means
thus red precipitate - however comminuted remains
the same - Chemistry shows that it consists of mer-
cury & oxygen - There is therefore something else
to be noticed, than mere numbers - weights or mea-
sure - in our attempts to define Chymistry.
For ages it has existed only as an art - About
a century ago it began to assume the form of a
science - but even now it is a science in its in-
fancy; every day is adding to our knowledge &
new deductions are constantly made. From the
wonderful improvements which have been made
on discoveries which were at the time apparently
of little importance, we have a right to con-

clude that all the facts of Chymistry, will, at some period, be brought into use for the benefit of Mankind.

General laws of Chemical Affinity.

We shall now state the General laws of Chymistry as now received - do not however receive them as infallible - for probably new discovered facts will show that we have been very erroneous

1st Chemical Affinity takes place only between bodies of different kinds. Flint - when joined to flint may colore but no change will occur - lime stone will not decompose lime stone.

2nd In all cases of Chemical action there is a change of properties - Acids or alkalies added to water - some of their properties will remain; in all other cases the properties are destroyed - Perhaps the great & peculiar feature of this Affinity is that it produces new properties in the substan

themselves— 2 If burned— produces new bodies with new properties. By this the temperature, colour, texture, odour, & taste of the bodies are altered—

1st Temperature— Heat is generally produced— sometimes cold— Exp.ts 1st If water be added to water of the same temperature— no heat is produced so also if oil of vitriol be added to oil of vit. under the same circumst.s no heat is evident. But if oil of vitriol be added to water of the same temperature the heat produced exceeds that of boiling water — — — This is applied to several useful purposes— it is the foundation of the principles on which the patent matches are made as in the following. Exp.t 2nd Let a taper, formed by mixing together equal parts of oxymuriate of pot.sh & sugar— be dipped into oil of vitriol— a chemical action takes place— heat

& flame are generated. This shows something different from a mechanical division of parts.

Expt 3rd In like manner gun-powder & phosphorus may be inflamed by the oil of vit.l

Expt 4th Let a little nitrate of copper be rolled up in a piece of tin-foil. upon adding a little water heat & often light will be generated. This I cannot explain but it does not depend on mechanical principles. Expt 4th Let strong nitrous acid be added to spirits of turpentine flame will be instantly produced.

Again the colour of the bodies exposed to chemical action is changed. Wherever there is a decomposition of any body there is likewise a change of colour. Thus none of our senses can inform us of what a body is composed, till it is subjected to chemical analysis.

Expt 1.st The process of making ink is one of

the simplest examples of this fact. Thus when I add a solution of the gallic acid to a solution of iron, a black colour is produced; thus two liquors, which are colourless, when united together make an ink.

Exp^{t} 2nd Iron may be detected in another way thus, if to a solut^{n} of a sulp. of iron, I add a solut^{n} of prussiate of potash. there will be a beautiful blue precipitate which is the prussiate of iron or the prussian blue.

Exp^{t} 3rd In manufacturing a yellow colour which is now much used in painting coaches, this chemical fact is illustrated, a solution of lead is added to a solution of a mineral found in this neighbourhood — a beautiful yellow colour is produced.

Exp^{t} 4th So also the common method employed by Chemists for ascertaining the presence of acid or of an alkali. An infus^{n} of the red cabbage or of bi

mus- becomes red by the addition of an acid- & is again changed to a blue colour by adding an alkali. - In this way other colours may be formed- indeed in almost every case, where bodies act chemically on one another, colour is destroyed, as well as every other property- Various beautiful colours are produced by the ~~sewer~~ chromic acid, mixed with solutions of the metals. Now all these experiments are not only amusing- by observing the sudden transition of one colour to another, but they are of real practical importance- observe the consequences: galls & iron will form an ink- therefore if I suspect the existence of iron in any substance- as for instance in mineral waters- I can determine whether my suspicions are correct- by adding the galls: or I may detect it by adding the prussiate of potash, which will form with the iron- the prussian blue. So also by

the infusion of Litmus, I can detect an acid where ever it may be - & also an alkali. By means of the Arsenic acid I can detect silver, mercury, or lead in their various minute combinations - If you write on paper by means of the solution of the sulphate of iron - you will not be able to read it - if however you wet this writing with the infusion of Galls it will immediately become apparent - This test is useful - as by it you may be able to read old writings where the letters are become almost invisible. This may also be assisted by the other test of iron, the Prussiate of Potash.

The form or texture of a body is also destroyed by Chemical Affinity. By it, solids are converted into fluids, fluids into solids; fluids are converted into gases, & gases into fluids: &c. &c.

Expt 1st — Here is a solution of the muriate of lime; — here also is a solution of the Sulphate of magnesia — 2 fluids — I mix them — it is a solid.

Expt 2nd When oil of vitriol is added to the carbonate of lime — a gas (the carbonic acid) is extricated & can be collected — Here is an example of a solid partially converted into a gas. Every lime stone building, from the hard marble, to the soft tufa stone consists partly of air, 44 parts out of the 100. —

— When a precipitate is not produced by the admixture of two fluids, in general, no chemical action takes place — but this is not always the case — Acid & water being mixed a change ensues, but this is not apparent. So also, when Spirits of wine & ~~camphor~~ Water are mingled — every one knows that a change is produced, & tho' there is no precipitate — its Specific Gravity & temperature are both

altered. From a knowledge of this fact, various frauds have been practised by the dealers in this article - & it has required great chemical skill to detect them - this has been done by an improved hydrometer. — Expt 1st If muriate of ammonia is decomposed by quicklime an invisible gas / the ammoniacal-gas / will be produced, having a strong, pungent odour - here then is a body not only converted, partly, into gas - but this gas possesses an odour - while the original body had no smell whatever. Expt 2nd If sulphuric acid be added to the muriate of soda - an invisible gas / the muriatic acid gas / will be extricated - having an odour - not possessed by the salt.

Expt 3rd If the ammoniacal gas / formed in Exper 1st / be mixed with the muriatic acid gas,

/procured in Exch^{d} of nd/ a solid body the Muriate of Ammon^{a} will be formed - Here then is a solid formed by the union of two gases.

— Look at the difference between a piece of metallic Lead, & litharge or red lead - it appears to be great - the only difference, however, is that the the lead in the litharge is combined with part of the the air of the atmosphere - The same may be observed between mercury & red precipitate - but in reality there is the same difference - What is there but Chemical principles which can produce, or explain these phenomena? Formerly, they were not understood by the Philosopher - & were looked upon by the vulgar as miraculous - but they do not happen at a distance - as in the Sun or Planets - they do not occur only in the closets of the Philosopher, or in the studies of the learned - but they

are manifest in every civilized place – & at every hour of the day. But the method by which they are produced – or the manner in which they can be obtained depends on Chymistry only. I have now explained the circumstances which occur in the action of bodies on each other, which are imputable to the laws of Chymistry – nothing else being capable of explaining the change which takes place in the form – temperature colour &c of bodies.

A 3rd Law of chemical Affinity is that it takes place between the minute parts of a body. Other attractions take place between large masses. Thus the tides are produced by the moon – the revolution of the earth by the attraction of the Sun – Thus also a ball of lead, suspended by a string on the side of a mountain will be drawn from the per

-pendicular. But Chymistry does not regard these large masses - but only their minute particles & hence the force of this affinity cannot be determined by weight - or numbers.

A 4th law of this attraction is that it takes place not only between two bodies - but between three, four, or many bodies. Ex 1st Let a piece of lime stone be exposed to heat - vapour is first driven off - then an air or gas - & the lime remains. There are 3 substances in the lime stone, but these are not all - the Vapour or water - consists of caloric - hydrogen & oxygen - The Air or carbonic acid - consists of caloric, carbon & oxygen. The Lime consists of a metalloid in union with oxygen - There are 5 bodies which enter into the composition of lime-stone - & by the union of these the lime stone can be remade

A 5th Law of Chemical Affinity is, that the affinity between 2 bodies may be dormant, till called into action by the intervention of a third.

2 Two substances may have an affinity for each other yet require a third substance to render this affinity effectual

Exp.t. If iron filings be added to water no action takes place & they would remain distinct, till the end of time. If however a little oil of vitriol be added to the mixture the ~~water~~ iron thus associated, acts on the water - decomposes it - its hydrogen is evolved & its oxygen unites with the iron - like 2 armies in a field - nearly equal - no engagement takes place till one of them receives a reinforcement - when an attack immediately ensues. So it does not follow, that two substances have no affinity for each other, because they do not act independently - it is for

Simple elective affinity. When one substance is added to another, composed of two articles - with the view of decomposing it - this is simple elective affinity - Thus when water is added to Camphorated Spirits - the water unites with the alcohol & the Camphor is precipitated - also when an acid is added to the mixture of water & iron, this also is simple elec. affy.

Double elective affinity. Where a compound substance is to be decomposed, it must be by a force stronger than the force by which holds them together. Thus, if the affinity of Camphor to alcohol be equal to 10 - water would not unite to the alcohol, unless its affinity was equal to 11. The force which holds the component parts together is called the quiescent attraction the force which another body exerts to separate them - is termed the divellent attraction. This is sometimes sufficiently great in one body as in simple elective affinity - but

Thus take the Sulph. of Magnesia & the Muriate of Lime — suppose the affinity of the Sulphuric acid to the Magnesia be equal to 4. & that of the muriatic acid to the Lime be equal to 6. Then the quiescent attraction will be equal to 10. Now no action can take place unless the divellent attrac^{s} are greater than 10. If the divellent attrac^{s} are equal to 18, then the bodies will be decomposed by a force equal to 8. This may be more evident by a diagram —

Muriate of Magnesia —

Sulph. of Mag.	Magne.	8	Mur. acid.	Mur. of Lime
	4	Divel. Attᵉ = 18 Quies. Attᵉ = 10 8	6	
	Sulph. Acid	10	Lime	

Sulphate of Lime.

Sometimes substances act on each other, not only by their affinities — but also in proportion to their quantity — a greater quantity compensating for

a weaker affinity - This arises from the necessity of the particles coming into contact before any action can take place; a greater number of particles therefore must act more speedily & powerfully. — It has been supposed, that bodies unite only in proper proportions - which are multiples or aliquot parts of each other; This I shall notice hereafter, when you will be better able to understand it. At present I may observe, - that altho' it has great probability, yet it is not made out by the only means which a Chemist should receive - viz by actual experiment.

I have now mentioned the leading facts, connected with chemical affinity - I shall therefore leave it for the present & proceed to the consideration of the particular objects of Chemical Research.

Atmospheric Air.

The old division of the simple elements of bodies was into air, earth, fire & water - & I do not know that this arrangement, with some varieties or modification, might not answer our modern purposes. The term air comprehends all aerial fluids, whether natural or produced by artificial means; The term has however for a long time been given to that fluid, which naturally exists, in which we live & move & which is also called the atmosphere - other airs are artificial - & are now usually termed gases. The properties of Atmospheric Air are either Mechanical or Chemical. As to the former, - air is considered as a mass, having properties subject to the laws of Mechanical Philosophy, & which can be measured. Chemistry however considers only its constituent parts.

Before entering on the Chemical properties of the

Atmosphere, it will be right to explain some of its mechanical properties, because frequent reference will be made to these; & it will therefore be necessary that you should have a general idea of them.

The Air is an invisible, tasteless, inodorous, incondensable fluid, that gravitates or has weight.

It is invisible or transparent. This is at once evident: as when we look at objects, we do not see the medium which surrounds them &c.

It has no colour. Sometimes there is an appearance of colour, as when a beam of the sun penetrates into a dark room, but this is altogether owing to heterogenous particles suspended in it. Saussure, a French philosopher of great research, & particularly distinguished for his meteorological & mineralogical observations, ascended the Alps in the progress of his travels; Previous to his ascent he formed an instrument the Cyanometer, so named

colour – He had painted on a board 51 shades of blue, from the darkest to the lightest. Furnished with this he ascended Mount Blanc, which is 15,000 ft above the level of the sea; & found, that in proportion to his ascent, the sky became of a deeper & deeper shade. Hence it follows – that, as he surmounted the region of vapour, the sky became of a deep blue colour – if he could have gone on – it would become black, that is, would have reflected no colour at all, or have been invisible. This would probably be the case on higher mountains – as on the Andes – mount Chimborago being more than 20. 000 ft. in height. It is a little singular that the conjectures of the antients should coincide, so nearly with the demonstrations of the Moderns: Strabo, an historian of some note conjectured that the highest mountain would not exceed 2 0,000 ft. Air therefore is invisible – & that it is colorless we may conclude from

the experiment of Saussure - that any colour is owing to heterogeneous substances.

The Atmosphere naturally has no smell or taste. All odours & tastes are owing to accidental circumstances. Thus the air in London, especially during foggy weather, has an evident taste - this perhaps may be the case in other large cities - but it is always owing to the admixture of other substances. There are no gases which show, that in its pure state, the air will produce any impression on the organs of taste or smell.

Atmospheric Air is incondensable; that is, it cannot by any means, at the common temperature, ~~of the atmosphere~~ be condensed into a solid substance, but always remains a permanently elastic, æriform fluid. It is true, that chemically considered its constituent parts may form component parts of a solid body - But air formed of the proper proportions - & under every vicissitude of temperature remains the same incondensable,

Besides these properties, it gravitates; that is, like dense bodies it presses towards the centre of the earth. The common instrument for measuring the weight of the atmosphere must be well known to you. I refer to the Barometer. The column of mercury in the tube is never higher than 31 inches - if made longer it immediately falls, the only reason of this is that the weight of the atmosphere will not support a higher column. Expt. 1st If I fill a long barometer tube with mercury & invert this in a vessel of the same it will remain somewhere between 29 & 31 inches. if on opening then be made at the upper extremity the merc. falls as the air is admitted - it follows that the weight of a column of air must be equal to the weight of a column of mercury which it supports. Expt 2nd Place the hand over the mouth of a receiver placed on the plate of an air pump - when a portion of the air is exhausted the hand will be pressed by the weight of the atmosp.

& firmly fixed. Exp^{t} 3rd " Take 2 hemispheres of brass which when united form a hollow sphere - they can be easily separated from each other, but let the air be exhausted from the cavity - & it will require a very great force to separate them. — To show that it is the air that supports the mercury in the barometer tube observe the following Exp^{t} Exp^{t} 4th " I place under a receiver, a short tube filled with & inverted in mercury. I exhaust the air from the receiver - & the merc^{y} falls in the tube, upon opening the cock & again filling the receiver with air, the mercury rises. Now you may remember, that in exp^{t} 1st I suffered the air to press on the top of the column of mercury - in this I remove the atmospheric pressure from the bottom of the column - & precisely the same effect is produced - the mercury falls into the vessel. Exp^{t} 5th As the air presses equally in all directions - therefore the greater the density & weight of a body - the easier will it overcome the resistance of the air - while falling - Thus a piece of [illegible] lb - & a piece of Paper will not fall with the same

velocity to the ground. In vacuo, however, were this resistance does not occur, they will reach the ground in the same time. Expt 6th If the air be exhausted from a long receiver, ~~to the top of~~ which is furnished with a plate & stop-cock, so that it can be removed from the pump, & this be placed in a vessel of water - the stop-cock being turned the water will rush into the receiver, from the pressure of the air without & a beautiful artificial fountain will be produced. — It is on this same principle that all our pumps are constructed - by means of the valve & piston a vacuum is formed in the pump - the pressure of the atmosphere exteriorly drives the water up to fill this vacuum. —— The greatest height to which the mercury in the barometer rises is, 31 inches. This is the case during clear weather, near the sea-shore - where the land is lowest & of course the column of air the lightest. Hence the barometer has been applied to measure the altitude of mountains. If at the sea-shore the mercury stands at 30 inches & the barometer be carried

* The vapour of water is lighter than air; therefore, a abundance of ~~not~~ aqueous vapour renders the air lighter, cæteris paribus.

up the Allegany mountains, it will be found, that the greater the ascent, the lower will the mercury fall. This arises from the circumstance, that in proportion as we ascend, the height of the column of air is shortened & the diameter being given, the weight is in proportion to the height. Therefore in elevated situations a less weight of air presses on the mercury & of course will support a less weight of mercury in the tube. The weight of the column of mercury will then be the exponent of the weight of the atmosphere.

The common purpose for which the barometer is employed is to determine the state of the atmosphere & to foretell changes of the weather. In proportion as the weather is clear & warm, a greater quantity of vapour is contained in the atmosphere, whether suspended or chemically combined is not, to my mind, perfectly made out; & in proportion to this quantity is the weight of the air. of course the mercury will rise in the tube. But if from cold, e-

electricity or any other cause the vapour ceases to be suspended or dissolved, the column of air is less heavy & the mercury falls. This rising & falling of the mercury depends however on other causes, which I cannot now explain, & which render its indications uncertain. This property of the atmosphere has been applied to a surgical operation, viz cupping. The usual method is to rarefy the air in the cup & apply it to the part but a more preferable mode, is to employ a small air-pump by which the air can be exhausted from the cup. —

In proportion as a boiling fluid is pressed upon, the greater heat is necessary to vapourize it. Thus water will, under the common pressure of the atmosphere, boil at 212° of Fah^t = but before it can boil, the heat must be sufficient to raise a column of ~~mercury~~ air equal to 29 or 30 inches of mercury: If therefore a part of this pressure be removed it will boil at a less degree of heat. Thus under the receiver of an air pump it can be made to boil at

176°. So also at the top of a mountain, it will boil with a less degree of heat, than at the sea-shore. Therefore in this way also we can determine the height of mountains. By noticing the difference between the boiling point of a fluid, in the two different situations

— Having now considered, as fully as is necessary, the mechanical properties of the atmosphere, we proceed to a chemical investigation of this fluid. We shall now discover properties, not reducible to weight & ~~numbers~~ numbers. The atmosphere, as submitted to the laws of Mechanics, & as it appears to our senses is a homogeneous fluid. Chemically examined it will be found divisible into several parts, which I shall soon show you. Of which are a gas called oxygen — another gas termed azote or nitrogen & a small quantity of carbonic acid which is to be found perpetually in every country, in every climate, under all circumstances & in every situation — whether ~~situated~~ high or low. Besides these there are usually found numerous heterogeneous substances,

not so much!

gas arising from the surface of the earth, produced by the decomposition of vegetable & animal matter as well as by several other processes. The Atmosphere, however, consists principally of two gases, the one totally incompetent of supporting fire & animal life the other eminently competent for the support of combustion & life.

The gas that will not support fire & the life of animals is on this account termed Azote: from two Greek words signifying a negation of life. The term, however, is not descriptive, as they are many other gases equally deleterious. It is better & more characteristically named Nitrogen from its being the base of the Nitric Acid.

That portion of the air which supports life is about 21 out of the 100 by measure or as about 1/5th. That portion which will not support life is about 79. or 4/5ths of the whole. The Carbonic Acid is a permanently component part of the Atmosphere but is extremely small being only 1/2 of a part in 100 parts: but this small portion can be shown. When I said that our

Atmosphere consists of $\frac{4}{5}$ lbs that will not support combustion & life & of $\frac{1}{5}$ lbs that will, I should show you this - but I cannot demonstrate the whole of this proposition - unless I should destroy the life of an animal, & whether we have any right to do this, merely for a philosophical curiosity is doubtful - but at any rate it would be an unpleasant sight to you. This I must therefore prove by argument. But as it respects combustion - I can show it by experiment.

I take this glass tube, which is closed at one end, & is divided into $\frac{1}{5}$ parts. I invert it, full of air over this candles & suffer its edge to pass under water, that there may be no access for the external air to the tube or vessel - Now if any portion of the air within the tube disappears, the water will rise & occupy its place & this disappearance will be produced by the combustion of the candles. The candles burn for a certain time & consumes a certain portion of the atmosphere in the tube the rising of the water indicates the quantity. This will

uniformly take place & is not the effect of accident in the present instance. I use two candles one lighter than the other - as the air in the upper part of the vessel will be consumed & the candle be extinguished sooner than in the lower part. This Exp^t shows - that the candle burns, whilst any of the gas which supports combust^n remains, & goes out when none of it remains - & it therefore is apparent that the residuum will not support combustion - Therefore the Air consists of two parts - one that will not support combustion - & another that will. —

— It is found by experiment - that oxygen or the gas which supports combustion - is often separated from the air & exists in combination with various substances - as the red-precipitate, the red lead - nitre - manganese &c This gas is an eminent supporter of Combustion.

In Combustion - the combination of oxygen with the body burnt - forms a compound possessing new properties - Therefore the body burnt combines with the gas that is consumed. — & Nitre - when placed in a retort & heated, gives out a gas which may be collected in the usual manner & which will support combus-

tion much more vividly than atmospheric air. Thus I plunge a taper lit this jar containing oxygen gas- & you perceive the brightness with which it burns. This brilliancy is greater when I immerse a piece of phosphorus into the same gas. In this gas if you make the experiment over water you will find that after the combustion has ceased the water will rise in the vessel- The reason of this is that during the combustion the phosphorus unites with the oxygen & forms Phosphoric Acid- this is absorbable by Water- it of course disappears & the water rises to occupy its place. By means of this gas we are enable to burn substances which under ordinary circumstances are incombustible- Thus I insert an iron wire to which is attached a minute portion of sulphur for the purpose of igniting it- into a glass of this gas- & you immediately see the wire burn ——— If I were to place a mouse under a jar filled with common air & placed over water- it would live a certain time &

would consume a certain portion of the air in consequence of which the water would rise, as you saw in the combustion of the candles.

Now it is evident, that the air is composed of two substances - & that one of these can be taken away by burning bodies in it - & also by animals breathing in it: it therefore follows, that in proportion as the oxygen of the atmosphere is destroyed or removed in the above manner, the air becomes less capable of supporting combustion & life: hence we may account for the sense of oppression, & the lowness of spirits which affect persons in rooms where there are many candles burning, * which are crouded with company, & where there is not a free circulation of air. Hence amusements, otherwise innocent, become dangerous by neglecting the proper chemical precautions for preserving the purity of the atmosphere.

There are other methods of testing the purity of the atmosphere besides those of breathing & com-

tion - Some of these I shall show you - They are termed Eudiametric experiments & all consist in compelling the oxygen to unite with other substances & thus taking it away. The term oxygen is derived from the Greek & signifies "the making an acid" - It is thus named - because in a great variety of cases it converts the substance, with which it unites, into an acid. As in the following case. I pour Nitric Acid upon copper - & subject it to a gentle heat - the acid is decomposed & a gas is formed - If this gas be mixed with atmospheric air - it unites with the oxygen & forms an acid - soluble in water. Thus I pass in - to this tube - filled with & inverted in water - two measures of common air - & afterwards one measure of this gas: you may see - that instead of 3 measures in the tube - there are only two - the gas uniting with the oxygen formed an acid - which was absorbed by the water & which therefore rose & occupied its place - - Again if I immerse a piece of blue

paper in the gas, produced by the decomposition of nitric Acid by copper - its colour will not be alter^d but if this gas be exposed to the atmosphere red fumes will form - which will speedily change the blue paper to a red colour indicating its acid properties.

Thus I have explained why one of the constituents of the air was named oxygen - I said, that it was the base of all acidity - this is not exactly the case, as there are two or three anomalies not yet explained, but as a general rule, it may be taken - that wherever there is an acid - that it is owing to the presence of oxygen - ——— I have now shown, that the Atmosphere is composed at least of two parts; whether these are mixed or chemically combined is not fully ascertained, probably combined as they are found in the same proportions - in low & elevated situations & in every part of the world; but whether one or the other they are easily separable by combustion - & by the formation of an acid - by which process one

part will be taken & four fifths of the whole will remain - which is incapable of supporting combustion & animal life. This gas which remains is called Azote or Nitrogen — azote because it is unfit for the purposes of life - this is not a characteristic of this gas - & it has with more propriety been called Nitrogen - as being the base of the Nitric Acid. I still have to show that nitrogen is not fit to support combustion - either as it is procured by taking away the oxygen from the atmosphere - or as obtained artificially from substances with which it is combined. I have then ~~to~~ to show that although this air will not support life or combustion yet when mixed with a due proportion of oxygen an air will be formed similar to that of the Atmosphere in all its properties. At present I have to show that after oxygen is removed from the air - the residuum will not support combustion - I plunge this lighted taper into this gas procured, as above di-

rated - You see it is instantly extinguished - & now the same thing is true, as to its not supporting life - for whatever will not support combustion will not support animal life - When I come to treat of the chemical nature of animal & vegetable substances I shall demonstrate what I must now, in some degree anticipate - it is that vegetables are composed chiefly of charcoal - & that animals differ from them - in containing but little charcoal & a large proportion of nitrogen - If I therefore pour some nitric acid - on these small pieces of beef & subject the whole to a gentle heat a gas will be produced, exactly, as that ~~formed~~ produced by combustion - This is the nitrogen which was a constituent part of the beef - - - Now if artificial oxygen or oxygen procured by artificial means from nitre & be added to the Nitrogen obtained by combustion - an air will be obtained exactly similar to that of the atmosphere - Thus I add this oxygen gas

which I have procured from the decomposition of Nitre by heat - to this nitrogen gas procured by combustion - I agitate them together so that they may completely unite - Now when I immerse a taper in this air so formed - you see that it burns exactly as it did in atmospheric air. The same thing will also appear, if I add to the oxygen, procured as above, some nitrogen gas - procured by the decomposition of animal substances. Thus atmospheric air may be shown to consist of two parts, oxygen & nitrogen - & it may also be remade by uniting these two.

There is however another gas in the composition of the Atmosphere almost inappreciable, although its presence is certain yet its quantity has not yet been accurately ascertained. It is supposed to be one part or half a part in every 100 parts. It is called carbonic Acid gas: you have seen me procure it from lime-stone - It is so named, because its basis is carbon or charcoal, being very pure

charcoal united with oxygen. We know, that it exists from this fact — when artificially procured — we find that it has the peculiar property of changing lime to lime stone, & when lime is exposed to the atmosphere it also is converted into lime stone; now as the lime in this case is only exposed to the air we are driven to the conclusion — that the gas was procured from this fluid. I ~~have~~ am now to lecture on the carbonic acid gas — but before I take up the experiments to shew how it is procured, & what are its properties — I must notice its base — or carbon.

Carbon or Charcoal —

By carbon — I mean pure charcoal — the appearance of which you all well know. If I place a piece of wood in a bottle & apply heat to it — & if I should connect this bottle with a series of others so as to collect any thing which should escape from the wood — there would come over first aeriform fluids — & then a vapour — & a solid substance would

remain behind. By the above apparatus I collect everything which escapes from the wood & I find 1st first a gas (hydrogen) 2nd a watery vapour & 3rd the solid residuum which is charcoal. It is this substance which enters into the composition of the atmosphere. — —

The Natural History of Charcoal. — It is the basis of all vegetable substances. It is the solid matter which remains after ~~this combustion~~ being burnt in close vessels. It is never found naturally in that state but is discovered combined ~~with~~ in a vast variety of forms. The purest specimen is the Diamond, which is carbon uncombined with any substance. It has been conjectured that both the diamond & charcoal contain oxygen: this is proved by no direct experiment — it is indirectly drawn from other facts: the quantity at any rate, must be very small. We may take it for granted, that it is pure carbon uncontaminated with any other substance

About the year 1664 some Philosophers at Florence discovered that when the diamond was exposed to heat it evaporated & could not be found. This experiment was not repeated & it was not pursued in any manner. The fact, however, was registered. This is one use of Chemistry to this we owe the fact, that no experiment which is carefully made & accurately recorded, but will at some time prove useful to mankind. Many examples might be adduced.

Soon after this, Sir Isaac Newton, in experimenting on the powers of bodies in refracting the rays of light found that all combustible bodies possessed stronger powers in this respect than incombustibles: having established this as a general law by numerous experiments, he found that water & diamond refracted like combustible bodies. He therefore conjectured, that the diamond was combustible & that water contained a combustible substance. Both of which have since been

demonstrated. – Newton was led ~~on~~ to this by the laws of Nat. Philosophy. It was not pursued, till Macquer & others in France experimented on this subject. They found that when exposed to heat, no substance, fluid or solid could be found, but that the air in the vessel was increased in quantity. When this was made in a receiver filled with atmospheric air its properties were totally altered, being very acid. This was evident by its precipitating lime from its watery solution, which is the greatest test of carbonic acid. The experiment was repeated in the following manner. A portion of the powdered diamond was placed in a watch glass; in a receiver filled with oxygen gas, over mercury & in this situation was evaporated by a lens; a vast quantity of carbonic acid was formed. Now where does this come from? – What is it? it is carbon & oxygen – the oxygen comes from the gas. Where does the carbon come from? Where but from the diamond. This has been repeated with the same re-

-ault. When charcoal was employed instead of the diamond the same gas was procured - & the charcoal totally disappeared, the conclusion therefore must be that they are chemically the same.

The diamond, you are well acquainted with, as repracting the rays of light more beautifully than any other substance. It is not found in the deep parts of the earth - but near the surface. It is procured from Southern countries - from the East Indies & South America - & has not yet been discovered in Northern countries - the reason of this is not known, the fact is all we have yet ascertained. The use of the diamond is to cut glass & it is employed for various ornamental purposes. — Carbon is often found naturally in diamond & in charcoal. It is found in Black Lead. This consists of iron & charcoal, chiefly of charcoal - as the experiment of heating it in close bottles - furnishes us with carbonic acid - with a small residuum of iron - There is only one mine, which produces this

lead in abundance & that is in the north of Engd.
Carbon is contained in all coal. Stone coal if
distilled & burnt, affords the same gas - except that
a greater quantity of iron & remain
It is the base of all coal - In this country we do
not know - that where charcoal is - there will be ma-
nufactories & where manufactures there will be riches
It is to her coal mines that Engd owes her great-
ness. There are two kinds of coal which are usual-
ly brought to this city: one burns with flame & smoke
& has considerable smell - This is a bituminous
coal - There is another which has no smell, burns
with a fierce flame & no smoke. The Bituminous
comes from the Northern & Eastern parts of the State
the other from the Southern & Western.
Carbon is procured from all bituminous sub-
stances - Bitumen is procured from Cuba
Derby-Shire in Engd & to come nearer home
in the Genesee country. Chemically analysed they
consist chiefly of Carbonic acid.

This finishes what I have to say on the Natural History of Carbon. I have now to say a few words on its Artificial History - or how it is procured. When charcoal is wanted for manufactories it is made by burning billets of wood - which are piled into a conical form & covered with earth - or turf. It is thus covered that the air may not have access to it - as then it would burn away - That the heat shall dissipate the gaseous & vapoury parts. In this process the gas & vapour passes into the atmosphere & are lost - they might be collected if it was conducted in close vessels as I formerly mentioned. As soon as the vapour ceases to rise - the process is finished & the avenues which had been made thro' the turf are to be closed - the remainder is charcoal. For smaller purposes it may be made in close vessels as above directed. Wood, on an average, contains 1/20th part its weight of charcoal - the rest is air or vapour: in bulk the charcoal rather exceeds the size of the wood. Sometimes when the Chemist wants a small portion of pure char-

-coal- he melts some lead- immerses a piece of wood in-
-to this- & retains it there, until it is completely charred, the
air & vapour being driven off by the heat of the lead.
Vegetable charcoal is not only the residuum after
burning in close vessels- it also is sometimes dispa-
-ted- for instance the dense smoke arising from burn-
-ing turpentine or oil is charcoal & forms lamp-black
Charcoal is sometimes formed from animal substances
usually from bone or ivory- & this possesses some pe-
culiar properties- The ivory black which is procured
in this way- is of a better black & has some peculiar pro-
-perties which will be here after noticed. Charcoal
therefore is the residuum of animal & vegetable sub-
-stances- after the gas & vapour have been dispersed-
Thus procured it possesses certain properties
In the first place it absorbs air & moisture; on this
account it should always be employed, as freshly made
as possible. If exposed to any gas, it will absorb
it: thus send up into a bottle filled with any parti-

-tious gas - it will become saturated with it & the gas can be again separated by means of heat.

It possesses several properties which render it very useful. It is indestructible by air or moisture - the alkalies which it seldom meets with dissolve it only in small proportion - & the acids do not touch it. It enters with the greatest difficulty into combination with common substances & at the common temperature of the atmosphere - Hence when wood is charred it lasts for a long time. The antient writings previous to the Christian ~~era~~ era, were generally made on which was the leaf of the papyrus. When Herculaneum & Pompeii were destroyed about the year 79 by the Volcanoes in their neighbourhood - the heat charred the wood & other vegetable substances which were then buried. When these cities were opened & examined, as they have been for the last 50 yrs - all the writings on papyrus were charred & found preserved - so that in many cases the writing could be read; some grain also was preserved in these cities, so well - that the rye could be distinguished from

the wheat. During Cæsar's first invasion of Britain, the Britons in opposing him made a stockade in the river Thames below where London now stands - 30 yrs ago this was taken up - & it was found, that the stakes, having been charred previous to their introduction, were perfectly as sound as ever. I have been informed that the signs at the corners of the streets in this city indicating the name of the street were prepared by writing the name with a black paint containing a large proportion of charcoal: After long exposure to the weather the wood was very much destroyed, except that covered by the black paint - the letters appearing on the sign in relief.

These facts have suggested an important improvement. In making a post & rail fence - it is very desirable to have it durable & it has been long known that with Hemlock some wood was preferable to others: as locust is better than pine but all of them rot very speedily - & always begin about the surface of the earth - Now it is found, that if this part be charred it will last for two or three generations at least. There is another use to

be noticed under this head. It is of importance, in writing deeds, that the ink should be very durable, & not be affected by the atmosphere. This is not the case with the common ink composed of galls & green vitriol. the galls evaporate & even the iron also. so that very great difficulty has occurred in old countries in making out a title to an estate. this country is not yet old enough to afford similar examples. but if no provision is made it will be the case here also. the whole difficulty will be prevented by adding a small quantity of ivory black to the ink in which it may be suspended by a mucilage. This ink would last as long as the substance on which the writing is made. — Charcoal will absorb all the gases. into whatever gas it is immersed it will become saturated with it. This is the foundation of its property of taking away the colour & odour of bodies. Thus whiskey, of which an immense quantity is made in Pennsa, in the county of Lancaster there are no less than 60 stills, possesses an unpleasant odour & also taste. If how-

ever it be filtered through charcoal, the peculiar flavour & smell is lost. — For the same reason charcoal is employed as a dentifrice and it may answer pretty well but I do not like it with this view for several reasons. It is very likely for it to contain a quantity of silicious earth which will scratch the enamel of the teeth — There are several vegetable substances which contain silex & it is not an unfrequent circumstance for charcoal to contain it. The best dentifrice which I know of which renders the teeth the whitest & injures them the least is composed of equal parts of vinegar & rose water. The common dentifrice contains crystals of tartar which is too acid. By this property of charcoal vinegar may be purified; it can be separated from its impurities & made of a light clear colour its strength remaining uninjured. For this purpose the ivory black or charcoal from animal substances is preferable to that from vegetable. The process consists merely in filtering the vine-

-gar brought a bed of the charcoal. Another use of the charcoal under this head is - that by it we can preserve meat liable to become putrid - & can even recover it when it is putrid. This last I have effected four times. A leg of Mutton was so putrid as to be very offensive to the smell - & no one could suppose that it could be eaten - I threw a shovel of hot coals into a pot containing boiling water - & having wiped the meat dry - put it in - the water soon became very offensive - it was then changed - fresh coals were thrown in - & in this way the mutton was restored & rendered very palatable. - There are several means of preserving meat to a certain degree - as by coagulating the Juices on the outside - by immersing it for a few minutes into hot water. Chemical decomposition will in this way be delayed - as it can never take place without a certain degree of heat & moisture - In this way, the portable soup is preserved for years - it

is prepared by boiling down the soup-till it becomes solid.
Another property of Charcoal is that it conducts heat badly. If you heat one end of a piece of charcoal, no matter how small it is-to a red heat-you can touch the other end without any injury. It therefore is not affected by the variations of the atmosphere, as to heat & cold. To me, as a chemist it is often necessary-that I should have a coal furnace on my table-that I need not be overcome by the heat, I surround this furnace with charcoal placed between its sides,-in this way although there may be a white heat on the inside. I can bear my hand on the outside.—In summer-& in those places where ice is by no means plenty-it is of importance to preserve it. A very good way, is to have a vessel made with double sides-so that there may be an inch between the inner & outer side-fill this space with charcoal-& have a cover to the vessel, made in the same manner-ice put into this will be kept for a long time.- There is another use, to which charcoal has not been much applied-& that is-for fueling

your houses. I am certain from many experiments which I have made with this view - that when wood is at $5 a cord - & charcoal at $8 for the 100 bushels - that the charcoal will go one 1/3 further - Hence it is, that the French Stoves for burning this are so economical - By the common method of heating our rooms - I am convinced 4 out of 5 parts of the heat are lost - the heat goes where you do not want it.

But there is another circumstance to be noticed - A greater heat is produced by a quantity of charcoal than by an equal quantity of wood. Bulk for bulk, the charcoal produces the most heat. As to the heat producible by different substances, I have ascertained that 483 parts by weight of pit coal will produce an equal quantity of heat as 1000 parts of dry oak. — By its property of absorbing gases, charcoal is useful in preserving water in long voyages — The credit of this discovery is due to a Russian Captain - who by charring the inside of his water casks - preserved the water for 3 yrs

untainted; It was as pure at the end of his voyage as when first taken in. ——

This finishes what I think it necessary to say to you on carbon - I have mentioned those uses to which it may be applied which I thought might prove advantageous to you - I have omitted others, which are connected only with particular pursuits. I now proceed to one of its combinations - Carbonic Acid, which forms part of the air of the Atmosphere; - In treating of this I shall, according to the plan laid down in these lectures, notice first its Natural History - secondly its Artificial History - or how procured - thirdly its properties - & fourthly the uses to which it is applied.

— Carbonic Acid Gas consists of carbon & oxygen chemically united. This combination is found in the Atmosphere: it is exhaled in all the processes of combustion, particularly in large towns & in their neighbourhood: it is formed in the process of respiration; it is exhaled from many cavities in the earth - from coal mines - from caverns - of which there is a very

celebrated one in Italy: it is found in the bottom of wells: it is given out by vegetables from the under surface of their leaves, ~~when~~ at that period of their vegetation in which they are not strongly acted on by the light, when they are strongly acted on by the light, vegetables give out oxygen or convert the carbonic acid into oxygen: it is found in all marble & limestones, forming 43 or 45 parts by weight: it is found in all the alkalies - in several of the earths - in magnesia - barytes - strontites &c. — Dr Black was the first who investigated this acid ~~with~~ with any accuracy - About the year 1757 he discovered it as a constituent part of lime-stone - of magnesia & of the alkalies - he obtained it from them - & also reformed them by adding the acid to their other constituents. Afterwards Priestly - Bergman & others pursued the subject & have given us all our present knowledge of this substance. Lavoisier first demonstrated, that it was given out by the lungs during respiration. He examined the al-

mosphere, with more accuracy than any one before him, & showed that as the air passes thro the lungs its oxygen united with the carbon of the blood & formed carbonic acid. This I shall presently demonstrate.

As to its Artificial History - carbonic acid is generally procured by Chemists from Lime stone. If muriatic acid be poured on lime stone - the lime stone is decomposed & the carbonic acid is disengaged - which may be collected in the usual manner. — It is composed of carbon or charcoal united with oxygen. The properties of oxygen you know: you have seen how brilliantly it supports combustion. If I pass this oxygen gas in which a taper burns so vividly, over burning charcoal, it is manifest, if any change is effected, it must be by the charcoal as there is nothing else which can operate on it: having passed this oxygen over charcoal I immerse a taper in it - you see that it is immediately extinguished. This is a great change. Now I will show you that the gas - which is procured from

If Seltzer water be employed instead of the simple acid the precipitation will be greater.

lime stone, extinguishes a candle exactly in the same way. This gas is heavier than atmospheric air: hence if I invert a receiver containing it over a candle the light will immediately go out. —— The common test of this acid employed by Chemists is lime water. Lime is soluble in water lime stone is insoluble – if therefore carbonic acid be added to lime water the lime will be precipitated in the form of lime stone – Thus I add some of this acid to this lime water, which is perfectly transparent, it immediately becomes turbid. This is owing to the lime stone diffused or mixed in the water, if it were dissolved, the solution would be clear. I observed that carbonic acid constitutes 42 parts or 45 by weight of all marbles & lime stones in nature. This I will now demonstrate – I place some muriatic acid in this vessel – in one of these scales: this I balance by placing weights in the opposite scale. I now add grs. 50 of White marble in powder to the muriatic acid & place a 50 gr weight in the opposite scale – the

whole ought now to balance - but you see that the vessel containing the acid is the lightest: to balance it, I must add grs. 22. therefore during the solution of 50 grs. of marble in muriat.ic acid ~~the~~ part of its weight equal to 22 grs was lost; nothing has escaped except the carbonic gas which must therefore have weighed grs. 22. Thus this marble contained of carbonic acid 44 parts in the 100. Since however solid, a body may appear - chemistry will often show that it is composed of aeriform substances. — I will now show that it is a component part of the air we expire. You have already seen that the oxygen of the air is destroyed by combustion - the same is done by respiration - Thus I fill this vessel with water & invert it in the same - by means of a bent tube - I blow into this vessel - the water is displaced & the vessel is filled with the air which I expire. Now I plunge a taper into this air & you see it is immediately extinguished; To show that fixed air is carbonic acid in this air, I breathe into this lime water - a precipitate is formed - or in other words lime stone,

The air we expire is therefore very different from that which we inspire - it is incapable of supporting combustion & consequently animal life. From this fact we may see another reason why crowded rooms, in which there is not a free circulation are oppressive: & also why the air in which charcoal has been burnt is so dangerous. Goodwin has shown by direct experiment: that when blood is deprived of its access of oxygen & is overloaded with carbon, it no longer acts as a stimulus to the heart - which therefore ceases to beat & the animal dies: in this way - submersion - hanging &c prove fatal - by preventing the access of oxygen.

Using lime water as a test - we can analyse any air which we find oppressive to us - If a tumbler is filled with water, & emptied in the room containing the air to be examined, it will of course be filled with that air - agitate this air with lime water - & the precipitation will indicate the presence of carbonic acid.

The fact - above alluded to - (page 68) that lime stone contains a very large portion of carbonic acid

is well known to farmers - masons &c - If they send a ~~ton~~ of lime stone to be burnt - they expect to receive only 1100-weight - if they received more they know, that it would not be good lime - it is still lime-stone. If ~~this~~ lime is exposed to the air it absorbs carbonic acid from it - so that in a few days - ~~1100 weight~~ ~~was~~ the lime which weighed 1100 - would weigh 1400 lbs. That this is owing to the carbonic acid you may readily ascertain by adding an acid - which will cause an effervescence. Hence the sooner lime is used after being burnt - the purer it will be. This is a fact of great importance. When a quantity of mortar is made - & left exposed to the air - its properties as a cement will in a few days be spoiled. & for this reason - mortar is a cement - because it is capable of absorbing carbonic acid, which converts it into a solid substance; but lime stone has not this property - & the mortar which has been exposed,

being converted into lime stone, is no longer capable of absorbing carb^c acid - & is therefore no better than chalk & sand mixed together. A wall built with such mortar is weak & pervious to air & moisture.

When lime is used in agriculture it should be burnt - the use of this is, not only that it should be reduced to powder - which could be more economically done by grinding, but that it might be deprived of its acid - lime-stone is insoluble in water - & can be therefore of no use as a manure - but the lime is soluble in water, & thus it can stimulate & invigorate the plants to which it is applied.

The facts - as to lime absorbing carbonic acid, in the several forms which have been mentioned - & thus being converted into lime stone demonstrate the existence of this air in the atmosphere - But I know of no direct exp^t to show the exact quantity which is present in a given portion of air.

When ... to ascertain this ... the carbonic

acid/- most of which I have already noticed but which may require a little more explanation.

You have seen, that it extinguishes a burning candle & you know that whatever will not support combustion is incapable of supporting animal life. This has been applied to a practical purpose - I mentioned, that carb^c acid is often found in wells - persons employed to clean them have been taught by experience, that a candle should always be let down, previous to any person entering it - & that if the candle is extinguished it would be dangerous to descend. Many experiments have been made to clear wells of this gas. Chemists have resorted to lime, which is thrown down; this is very good as far as it goes - but a large quantity of lime must be employed - especially as it passes so quickly thro' the gas. - Gunpowder has been exploded - but this produces a gas more deleterious than the one it is intended to remove - The only effectual method that I know, is to pump it out - let a hose down into the well - & by a common pump to the well

orifice, the whole, with a little patience will be removed. —— The Carbonic Acid is absorbable by water. If a portion of this gas be collected in a receiver over water & the hand then be placed on the mouth of the vessel so as to close it - it will be found that after the water & the gas have been agitated together for a short time, the hand will be fixed on the receiver & so strongly by that the weight of the receiver will not separate them. This indicates that a vacuum has been formed within - which could only be produced by the water absorbing the gas. It is, on this principle, that the mineral waters of Seltzer - Aix la Chapelle & other places in Germany are formed. In Volcanic countries the process followed by nature is the following. The lava issuing from Volcanoes must necessarily be of a very high temperature - & when it meets with a bed of lime stone, will decompose it in the same manner as is done by the common method of burning in a kiln. The lime thus formed will be mixed & carried away with the lava. Part of the acid will

escape thro' the fissures in the lava, but a large portion will not escape - as is evident from the cavities which are found in the lava - This acid, meeting with water combines with it, & the pressure increases this combination - In this way the springs at Aix la Chapelle - at Seltzer &c are formed. The carbonic acid gives a brisk, sparkling, slightly acidulous taste to any fluid with which it combines. Knowing how nature operates, we imitate her in our laboratories. Dr Priestly first suggested the possibility of impregnating water with this gas. He effected this by first filling two bladders - one with water & the other with this gas - connecting them by a tube - & then intimately mixing the two fluids - by driving them from one bladder into the other. Several methods have since been adopted - the most common is to fill a gazometer with carbonic acid - then by means of a forcing pump - connected with the gazometer by a tube - the acid may be withdrawn, & driven into a vessel containing water: until

the water is fully saturated. The vessell is usually made of copper having its inner surface tinned. In time, this tinning is acted on by the acid & is destroyed in which case the copper becomes dissolved & communicates a taste to the fluid: which also becomes hurtful, especially to those of a delicate stomach. You should therefore never use the Seltzer water which leaves a metallic taste in the mouth. This water is slightly acidulous & independant of its own medical virtues - is an agreable vehicle of taking disgusting medicines - especially the alkalies - In this way a much larger quantity of Potash or Soda can be taken than by the mere solution in water.

I have now treated of the third component part of the atmosphere - These three gases - the oxygen - the nitrogen & the carbonic acid - are united - probably chemically & form the Air of our Atmosphere - the properties - of this, both mechanical & chemical I

now proceed to another fluid which is very common but which is not on that account well known — I allude to Water —

Water

I shall as usual give you the Natural History of water — & then its Artificial or Chemical —

First then we are to consider water as a simple element or mass. Water is found as ice, as snow, as river water, as rain-water, as spring water, as dew as vapour, as mineral water — as Sea water — First water exists as ice, when the heat of the atmosphere is lessened to 32° of Fahrenheit — water commonly freezes — this seems to be its natural state. ~~of ice~~ As when a portion of heat is added to ice — it becomes water — & when the heat is greater vapour is formed. In the form of ice, water is solid, & crystalline. It crystallizes in needle formed (crystals) which cross each other at certain angles. As it crystallizes — it occupies more room. this fact is shown by the breaking of

× Doubtful

a vessel in which water is frozen — This enlargement begins at 32° or before — if however the water is kept still it may be cooled to a lower point than 32°. The force with which it expands on freezing is shown by an experiment of an Officer at Quebec. He took a strong spherical vessel — filled it with water — & having screwed on the top very tightly he exposed it to the air during the winter — The vessel was burst with a loud report — This must be nearly equal to the force of steam — as it would require a great accumulation of this fluid to break such a vessel. — In a river ice forms first at the bottom — & this for two reasons — 1st because it is more still there — & 2nd because the earth is a better conductor of heat. This fact is well known at ferries — where the ferrymen often loosen the ice at the bottom — which being lighter, than the water, swims on the surface. — Water is

elastic: when thrown on the ground it rebounds. It is transparent. — When I speak of heat I shall show, that when ice is at 32°, the water which is formed from it will also be 32°. Yet that 142° of heat is absorbed before the ice is converted into water. This will explain, why melting snow produces a greater sensation of cold, than water at the same temperature. — When at sea, there are two methods of procuring fresh water. The first is by freezing the sea water, when little or no salt will remain in the ice; the second is by distilling, none of the salts rising with the vapour. — Liquors may be concentrated by freezing; thus vinegar may be made stronger by exposure to cold. A part will freeze & this will contain much less acid, than the part which does not. Wine may be treated in the same way, but its flavour is injured by it. Cyder is often concentrated by this means & is not injured. Ice, altho' apparently so brittle, is capable

of great resistance. Catharine of Russia had a palace made of ice - dinners were prepared in it - the culinary articles were of ice - & ice cannon were fired. — Snow is frozen vapour: it is formed in the higher regions of the Atmosphere where it is colder than near the surface of the earth. Snow is supposed to contain particles which act as manure & fertilize the plant. No chemical analysis confirms this supposition - there are no saline substances in it & indeed it does not differ from distilled water - Its good effect can be very satisfactorily accounted for, by its protecting the plants from the severities of the season. — There is, in the Western part of our country from Lake Erie to the confines of Virginia - a disease, termed the Goitre - It consists in a morbid enlargement of the thyroid gland. It attacks young females, more frequently than males. At Pittsburgh - 3 out of 5 females have it & per-

2 out of 5 only - Many out-grow it - but in numerous cases it remains for life - This disease is known among the Alps - & also in England in Derby-shire. The common opinion as to the origin of this is - that it is produced by drinking snow water. That this is not the case, is evident - as no snow water is used at Pittsburgh - but a clear proof is that the disease prevails at Sumatra in the E. Indies where snow is never seen - & it is unknown in Greenland where the snow is always present. It has been attributed to the vapour from burning coals; but coals are not burnt in Washington County or at Sumatra - It has also been attributed to the confined air of the vallies; but there are no vallies at - Pittsburgh - in Fayette County &c - I do not know what is the cause of this singular affection; but I know something of its cure. This can be effected by good living & by a temperate application

I have known one case cured by the use of Barbadoes – & it is useful to wear a net cloth containing salt – – – Water is also found in Rivers. There are drains, by which the water is carried off which is unnecessary to fertilize the earth or to support animal life. They are formed by vapours which arise from the sea – The heat dissolves the water of the ocean & holds it in solution. it is then carried by the winds to distant places & where there is a diminished temperature, it falls in the form of rain, vapour or dew. This, in a general way is the process by which rivers are formed. Rivers are either pure or impure. The impurities arise from the salts and earths which are dissolved or suspended in them which they derive from the countries through which they flow. Hence river water is purest where the country is the most barren & sterile – as occurs in stony countries – In rich tracts of land all vegetable & saline matters are dissolved – & the earthy

Why?

particles are suspended in it.

All rivers are colder at the bottom than at the top - This was proved by Mr Elliott on one of our lakes - who found, that the thermometer indicated a diminution of temperature - the deeper it was immersed - By washing away their banks, all rivers gradually widen their channel - on this account we find that in new, uncultivated countries they are deeper & more impetuous, than in countries which have been long cleared & cultivated - In old countries also, evaporation is greater - as the sun's rays are more directly applied to the cleared surface - In all rivers, islands are to be found at their mouths - This is so constant, that it has given rise to a theory - which is not without plausibility, that the ocean will, in time be filled up. This is not evident in one generation - but look at History - & you will find, that altho' in some places the sea appears to have gained

When water is evaporated & held dissolved by heat. It is again condensed by cold not only rivers but springs also are formed. This is effected by the water sinking in the earth, & again rising to the surface, by the well known property of water in always finding its own level. Springs, like rivers, contain saline bodies in solution: having been filtered in passing thro' the ground, they are transparent & clear - no earthy particles are diffused thro' them - but no filtration will separate those bodies which are chemically dissolved. Hence the deeper a spring is there is, generally speaking a greater quantity of saline matter in it. In this city we have in use spring & river water. In common life the question is, will they wash? that is will soap be dissolved in them or will it be curdled. A solution of Nitrate of Silver is a better test. The pump or spring water contains many salts in solution - while the hydrant or river water con-

tains very few. If we wish to detect sulphur in this water we add a little of the mur. of Barytes ÷ the oxalate of ammonia is the test of lime: galls is the test of iron. Owing to this property of dissolving salts, water in its passage thro' the earth dissolves various mineral salts. Thus our mineral waters are formed. Most springs in the country which have a bad taste & a fetid smell are termed mineral but very few of them contain as many salts, as the waters in this city. The mineral spring near Carlisle contained less calcareous matter than the water commonly used in that city. In a pint of water taken from a pump in Second St in this city grs. vij of salt were ~~found~~ found. This is much more than is contained in any mineral water in the U. States.

Water also appears in the form of vapour & dew. When the abstraction of heat is slow dew is formed. Hence we always first see it on the banks of rivers, on the edges of hills mountains &c. Hence also vapour is condensed on the sides of a vessel, in

which a cold fluid is poured.

If the Theory above alluded to, be correct that a large quantity of heat is absorbed while a solid is converted into a fluid - or a fluid into a vapour - & as evaporation is always in proportion to the surface exposed we can easily understand why a person is cooler in proportion to the increase of perspiration. When the temperature is about 65° - & when moderate exercise is taken - the fluid discharged from the skin of a healthy man is about lbs. v. in the 24 hrs.

Upon this principle liquors are cooled by putting them in bags of skin where part is evaporated from the surface - as is done in Africa. In India porous vessels are used with the same intention: the vessels are made - by mixing a quantity of salt with the earth: after being baked, the salt being soluble is washed away - & leaves the vessel porous.

The Atmosphere contains always a portion of water ~~soluble~~ dissolved. Below 60° the breath is visible - that is - the vapour, which was held in solution

by the heated air of the lungs is condensed by the cold
er air of the atmosphere & is therefore seen. Thus the
smoke of Vesuvius is always seen in rainy weather,
& it is in consequence of the evaporation from an
animal that dogs are enabled to hunt by the scent.

Dr Watson found that ℥viij of dry salt of tartar, in
8 hrs- from 11 o'clock in the morning till 2. & on a
clear day absorbed ℥ij of water- in a few days it
weighed ℥x ij. Upon exposure to heat- ℥iv of water
were obtained- leaving the original salt behind.

Sulphuric Acid in 12 months will absorb its own
weight of water- In England- at New Market- it
is required that the jockey's should only be of a certain
weight- & they are therefore in the habit of sweating
them very profusely. A jockey, who had been sweated,
gained, from 9 o'clock in the morning to 10, ℥xxx.
by absorption- having in this time drank only ½ a pint
of wine ——— When water is scarce at sea, thirst
may be moderated by bathing in the salt water.

Evaporation is greater as pressure is removed- Thus

water will boil with a less degree of heat on the top of a mountain than at the sea shore - Hence the boiling point of water is in some measure the exponent of the pressure of the Atmosphere.

Water exists also as sea water — Many conjectures have been made as to the question - how the sea obtains its saltness? This I shall consider in another place, at present I shall however make one or two observations - If I take an orange or an onion I can take off peal after peal - Still at last a solid portion will remain. This will give a description of our Globe, so far as we know anything about it. There is a nucleus - of which we know nothing - I can say nothing. By experiments numerous & diversified - & made by scientific & skilful men - it is ~~established~~ concluded that the mean density of the earth is 5 or 5½ times greater than water. Further than this we know nothing. The deepest mines have at the utmost

extended only 1100. yards. So that we have hardly penetrated the skin of the orange. But as far as we have gone, we find the earth composed of strata or as they are termed by geologists - "formations" - Of these formations, the granite is the lowest to which we have yet arrived - These surround the earth - & are to be found in all situations on its surface - & in the same relative situation as to each other. This is so universally the case - that I have no hesitation in adopting it as a general rule. About 6 - or perhaps 7 or 8 of these formations intervene between the granite strata & that of rock salt. This last formation I suspect passes around the earth - it can be traced all through this country - from Pascagoula by in the North East - to the country west of the Mississippi in a South Western direction - If on Allison's Map of the U. States a pin be fixed at the Salt Lake in Genesee County & a thread be passed from this to the Salt river west of the Mississippi this will

cut all the salt springs in the U. S. This is also the case in Poland & in England - & as far as facts are yet known enable us to judge, we may conclude that it regularly surrounds the earth. Now in the revolutions to which the earth has been subjected - chiefly by the action of Volcanic fires this regularity is in some instances destroyed - & the formations disrupturred & mixed - The ocean which is more extensive, than the land, must in such cases be brought into contact with the rock salt: indeed as this formation is probably in every part of the globe & not at a very great depth - there is no difficulty in accounting for the saltness of the sea - The peculiarity of the sea salt is - that with it there is some magnesia - & Glauber's salt - in every other respect it is exactly similar to the rock salt.

As to the depth of the Ocean there have been many conjectures - it has been thought to be ¼ of a mile but we have no facts to go upon.

The only useful purpose to be noticed under this

head, is, that when sea water is frozen as in high latitudes it contains very little salt. It may be used as drink. I may observe, however, that the waste fuel in a vessel will be sufficient to supply the whole crew with distilled water. Sea water should be distilled in gold or silver vessels; even glass is acted on & part comes over with the vapour. This has been suspected for some time - but is ascertainedly by Mr Davy to be a matter of fact. There is no earth which water will not dissolve. Water is pure in proportion to its lightness - salts dissolved in it increase its density. They add much less to its bulk than they do to its weight. On account of its greater density it requires more heat to make it boil. Chemists can in this way regulate their heat very well - by adding more or less salt to water as they wish a temperature greater than boiling water. Pure water has no taste or smell - it is more penetrating. Thus snow water penetrates

more than spring water - It is more elastic - it sounds more - It is softer to the touch - It does not curdle soap - but they mix smoothly. It will dissolve a certain portion of a saline substance - but no more of that substance - altho' - it will dissolve more of another salt - The English take the Specific Gravities of bodies always at the temperature of 60° as this is about the heat on a moderate, pleasant day; at this temperature a cubic foot of water weighs 1000 oz avoirdupoise - In this country & in England this is taken as the standard of weights & measures. In France another method is adopted - by measuring accurately the arc of a Meridian. It may be allowable here to mention a fact which at first sight does not altogether creditable, From several considerations & from measuring the base of the great Egyptian Pyramid - it appears, that the ancients had some knowledge of this mode of measuring.

Hitherto I have been considering water as a

homogenous mass - without any relation to its chemical History - But it is not a homogeneous substance a simple element, ~~but~~ it is a compound - composed of two gases, oxygen - of which you have seen & heard so much & of hydrogen. I shall first show, that hydrogen enters into its composition. In a gun barrel I place some iron filings, the middle of this, I heat, by means of a small furnace - till it is red hot - while in this state I cause some water to flow thro' the tube - it is first vaporized - & then decomposed - Its oxygen unites with the filings of the hydrogen passes over - which is to be collected in the Pneumatic trough. That it is hydrogen you may be satisfied by applying a lighted taper to it - you see it fires with a slight report. You see therefore that hydrogen is a component part of water - To show you that oxygen is also a part - I will burn these two gases together - & water will be formed - In this gazometer - I have the two gases - separated from each other by a partition. Here

is a cock communicating with the hydrogen gas- & another communicating with the oxygen gas. I turn these cocks & set fire to the gas (hydrogen) as it escapes in contact with the oxygen. Upon applying this dry piece of iron to the blaze, you see that in a few moments it becomes quite moist. Now, as there is nothing, but the two gases which are burnt, concerned in this process- we have a right to conclude that water is formed by the combination of oxygen & hydrogen gases- especially as I have already shown, that hydrogen is a constituent part of this fluid. — Water is also decomposed- & hydrogen gas is extricated by adding diluted oil of vitriol to iron filings- to Zinc &c. &c. This is the usual method of procuring hydrogen gas. In this case the acid has no action on the iron, & the iron has no action on the water but the acid & iron united, decompose the water- its oxygen unites with the iron & the hydrogen is evolved. Hydrogen gas is the lightest of all the gases- & has hence been employed for raising balloons, as I shall hereafter more particularly explain. — It is peculiarly in-

-flammable; as it fires more easily than any other bo-dy- Oxygen however must be present- as air must, no body whatever can take fire. If a jar of this gas be inverted, the gas being lighter than atmospheric air will not escape, a burning taper being immersed in it will fire the external surface but will immedi-ately be extinguished. If the jar be slowly turned upwards so as to admit the atmospheric air the hydrogen gas will speedily be ~~inflamed~~ burnt with a slight explosion. This explosion arises from the sudden condensation of the two gases. If I throw in some hydrogen gas, into this instrument called an air pistol, & set fire to it- the explosion will be much greater- as the combustion takes place in a confined place.— That hydrogen is a com-ponent part of water, I have shown by burning to-gether oxygen & hydrogen gases & thus forming water; I am now to show, that the combustion of any substance containing hydrogen, will form water-

If I pour some ether on water- it floats on the surface- it does not unite with water, & there-

-pose has no affinity for it. This is more evident by
setting fire to the ether, which will burn on the surface
of the water, manifestly showing, that no union or mix-
ture has taken place between them. If therefore I
show that water is formed during the combustion of
ether, it must be by some component part of the e-
-ther, uniting with the oxygen of the atmosphere.
Thus when it is burnt in a receiver - the sides of
the vessel will be found moist.
Water also can be decomposed by Galvanism.
If the wires from the opposite ends of a Galvanic
apparatus be immersed in a vessel of water - the wa-
-ter disappears slowly & gases are evolved. If these be col-
-lected & fired - they will burn with a slight explo-
-sion.
I must now say something more particularly
of Hydrogen gas. This is seldom found pure ex-
-cept in the higher regions of the Atmosphere. Here
we suppose that it is often fired in contact with o-

oxygen by the electric spark. In this way the Lightning is formed by the combustion of the hydrogen, the Thunder by the sudden condensation of the gases & the rain, which always follows a clap of thunder, is produced by the union of the oxygen & hydrogen gases. This is an easy way of explaining the above phenomena, & is probably the true way, altho' we cannot actually demonstrate it.

— Hydrogen is often found combined in various forms. It is found where from a hot Sun, animal & vegetable substances are decomposed. If the stagnant fluid of a marsh be stirred the gas which arises, is hydrogen — in these cases it is combined with carbon —

In consequence of hydrogen being involved in marshy the philosophers of the present day have endeavoured to explain by its combustion the well known phenomena of the jack a lantern or Will o' wisp. A friend of mine, on whose acuteness & judgment, I place perfect reliance, while riding towards the close of the day observed a will o' wisp fly before his horses. Curiosity induced him to pursue it — on coming to a hedge, he found, that it did not pass thro' the hedge — but went

over it. He continued the pursuit & found, that it also went over another hedge. This, at first, surprised him. & upon the common supposition of its being a gas it is not to be accounted for; the idea immediately ~~arose~~ arose in his mind that the will o' wisp was in reality a species of fire-fly & not a gas. In this explanation I acquiesce —— Hydrogen with carbon forms the carburetted hydrogen gas or as it is usually termed, the fire-damp in flammable air. This is the fire damp of miners, & is very often found in coal mines where it is very dangerous as the least flame would explode it. I remember visiting the mines at White-Haven in Eng^d which run 3/4 of a mile under the sea for the last 300 or 400 yds. we could not carry a candle for fear of the explosion. It was in these mines, that they first procured light by means of a flint & steel. A man wearing a brass plate of ~~steel~~ flint & having a steel roller between his feet which could be turned with considerable velocity upon stooping down, so that the cutting edges of the wheel might strike the flint, produced sufficient light for

himself & others - for it is a peculiarity of this gas, that it will not explode from a spark - altho it will from a flame - Notwithstanding this - numbers from accident or carelessness perish every year - Sir Humphry Davy - who has in many instances made theory subservient to practical purposes, has invented a lamp by which light can be had without danger - This lamp is formed of small wire forming a network like gauze - so fine that 100 apertures exist in the space of an inch - Here the quantities of gas are admitted so steadily & so constantly - that it will very rarely explode - & if it should explode - it will only extinguish the candle; the air exterior will not be inflamed - The theory of this has not been explained in Engl satisfactorily - altho many attempts have been made - I however think that it may be explained - If a flame be applied to a mixture of oxygen & hydrogen gases issuing from a gazometer - it will be fired - but the gases in the vessel will not be inflamed - for this evident reason -

that the current of gas is constantly outward. If the gas pushed inward the flame would immediately fire & explode the whole of the gases to the great danger of the Operator — So it is in the lamp — the vacuum constantly produced by the heat is as constantly supplied by the air from without which flows steadily & in sufficient quantity thro' the small apertures of the network. The current of gas ~~from~~ is thus constantly inwards & any explosion must therefore be confined to this place. —— Hydrogen is often combined with sulphur — as in the sulphur waters — forming the sulphuretted hydrogen gas. These waters are very common in this country — Virg.a, Penn.a, Virginia the Genesee country At the mouth of the Chippewa river this gas issues. & if a keg be placed over the opening thro' which it issues & the gas be inflamed — it will burn with a flame as wide as the keg. These waters are much used in cutaneous diseases. ——

Hydrogen gas is much lighter than atmospheric air, being to air as 1 to 13½. From this property it has been employed in ballloons. A French man by the name

of Mongolfier first suggested & put into execution the idea that a vessel might be raised in the air. He made a balloon of paper, & by rarefying the air within it, by means of heat. he found that the difference between the rarefied air & the common air would be so great that the vessel or balloon of paper would rise. He then tried a silk balloon which succeeding he went on a larger scale & was very successful. The first balloon so prepared as to raise a man went up from near by Lyons in the year 1782. or 3. This subject was pursued in France, with more perseverance than any where else.

These experiments of Mongolfier being known two Gentlemen about the same time endeavoured to raise bodies by a fluid much lighter than atmospheric air. A balloon filled with hydrogen gas was raised in France on the 27th August 1783. Cavallo in Engd had filled soap bubbles with this gas but did not prosecute the subject. Rozier in France, ascended in a balloon in Dec 1783. In this country Dr Rittenhouse & Judge Hopkins raised a balloon in which a man ascend-

-ed - By means of a rope the balloon was prevented from gaining higher than 10ô ft". In 1784 the raising of balloons was a common experiment. Blanchard repeatedly crossed over the English Channel in them The first person who ascended in Eng" was Mr

the professor under whom I studied Anatomy

—— As yet I do not know that balloons have been applied to any useful purpose; unless it is - that they have verified some Philosophical theories: as the constitution of the atmosphere - By them, the air has been examined at different distances from the earth, & it is found that at every height its composition is exactly the same. — By them also it has been ascertained that there are currents in the atmosphere - the velocity of which is much greater than would, "a priori" be expected. - They often go at the rate of 90, miles an hour, & in a direction contrary to that in which the clouds are flying. The reason why these should be formed is not very clear - perhaps it is owing to the ascension of heated air from the earth while cool air rushes in to fill its place. In this way

the temperature of different parts of the earth is in some measure equalized - & no one part is suffered to become too hot for the safety of its inhabitants. —

The currents in the air have been ascertained also by the progress of storms. This was first attended to in this country by Dr. Franklin - who computed that a storm passed along our Atlantic coast from Boston to Charleston at the rate of 90 miles an hour. —

During the French revolution balloons were employed to investigate the situation & position of enemies. Persons ascended in them to a certain height, which was regulated by ropes - & which was beyond the reach of the artillery - & were thus enabled to have a bird's eye view of their enemy's forces. —

Many experiments have been made to direct balloons in the air - but hitherto ineffectually. A balloon in the air is very different from a vessel at sea. In this there are two elements - which can be managed one against the other - the wind against the current & the current against the wind - Here also a rudder can be employed. But in the former case - there is only

It is customary to exhibit an experiment while lecturing on this subject which is rather singular. This I shall show you. It consists in burning hydrogen gas in tubes of different calibre by which a musical sound will be produced. I find however, in passing common air, thro a narrow tube that a sound not very unlike it, is to be observed. air passing with velocity thro' a narrow aperture will produce a sound. In the case of the burning of hydrogen as above directed. this effect is modified & increased by the condensation of the gases forming water but I do not think, that it is a peculiarity of this gas.

In the English publications you may see an account of a new kind of fire, which is said lately to have been discovered. Several years ago Mr Newman invented a blow-pipe. this consisted of a box to which was attached a forcing syringe & a tube with a stop-cock. By means of the syringe a quantity of air was condensed in the box, when the stop cock was opened, this air would rush thro' the pipe with considerable velocity. Dr Clarke of Cambridge in Engd thought, that he had discovered something new; when he condensed into Newman's box a mix-

ture of ~~of~~ hydrogen & oxygen gases in proportion in which they form water - ⅔ of the former to ⅓ of the latter by bulk, & employed this mixture in a blow pipe. Numerous experiments have been made by this - on bodies which have hitherto been insensible - conducted chiefly by Clarke & Newman. — The first person, however who conceived the idea of attaining an intense heat by burning together these two gases was Mr Robert Hare of this city. He not only formed the idea - but actually put it into execution by a machine which he invented - & I do not know, that a single substance has been fused in Engd which had not been previously done by Mr Hare. This discovery was made by him in 1801 or 1802 - & it was published in the transactions of the Amer Philosphl Society in 1803. This was propagated thro' Europe - it was translated into the French & was noticed slightly by the British periodical works. The machine of Mr Hare was too complicated - & a second one was not made - as Mr Cloud of the Mint has introduced one, which is infinitely more simple & convenient — a description of this was published in 1809. You may see how brilliant by the

metals burn in these gases, by exposing portions of ~~it~~ them, to the mixture when inflamed.

The Chemical combinations of Hydrogen are as inflammable as itself. In pursuing the Natural & Artificial History of this gas, I shall notice all its combinations. Hydrogen Chemically combines with carbon — also with sulphur — with phosphorus & with arsenic

First Hydrogen combines Chemically with Carbon forming the Carburetted Hydrogen Gas. This is found naturally under all circumstances, where a gas is found issuing out of the earth. It forms the fire damp from springs — it is produced from decompositions in the earth — & it is plentifully found in coal mines. As carbon unites with oxygen — & as Hydrogen unites with oxygen so also the combination of these, forming the carburetted hydrogen will unite with oxygen, or in other words, will burn. This gas as produced from coals is very prevalent in coal countries as in England. In travelling on the main road from Liverpool to London on a dark night 20 or 30 fires may be seen, issuing from the Earth; these are from the carburetted hydrogen from the decompo-

-sition of coal, escaping thro' the cracks & fissures of the earth. I have already noticed the danger arising from the collection of this gas in mines. I explained Sir Humphry Davy's lamp. I am now to shew the artificial method of procuring it & to point out its uses: hitherto we have only attended to its dreadful effects, but under proper management it proves very useful & subservient to our wants & comforts. Whenever hydrogen is disengaged from any substance containing carbon we find that the carbon is dissolved: thus when hydrogen gas, procured by the decomposition of water is passed over red-hot charcoal carburetted hydrogen is formed. As the solid part of all vegetable substances consists of carbon we find, that hydrogen gas as procured from them holds carbon in solution & forms the gas we are now considering. This gas therefore can be procured from passing hydrogen gas over red-hot charcoal: also from moistened charcoal in this case the water is decomposed its hydrogen uniting with the carbon: it is made by decomposing any vegetable sub-

-stance it can be distilled from pit coal - from pine knot, from wood - from pitch, tar, rezin, from alcohol, from Ether &c &c. In distilling pine dust there comes over first water; then a stinking oil, which if returned would be decomposed; & finally the carburetted hydrogen. This gas is distinguished from hydrogen by the flame which it produces - which is more vivid & brilliant than that from hydrogen - very much resembling the flame of a candle. I will show you the flame of this gas - & the manner in which it is procured from different substances. Expt 1st By placing some saw dust in a gun-barrel & heating it in a furnace - this gas will be procured - Expt 2nd If coal be employed - the same gas will come over in greater abundance - an empyreumatic oil also is collected which is very unpleasant - this may be removed by washing it with lime water which absorbs the oil. Expt 4. Another method of procuring it affords an instance of a change of form & properties by means of heat. If ether be placed in a retort & be exposed to heat - it will be found, that this fluid is converted into a <u>permanent</u> gas; this is the

carburetted hydrogen - but as formed from Ether, it contains less carbon; & does not therefore burn so brilliantly.

gr.[2]

When carburetted hydrogen gas is burnt, what takes place? you know, that in all cases of combustion, oxygen unites with the burning body. In the present instance oxygen unites with the hydrogen & forms water - it also unites with the carbon & forms carbonic acid: the test of carbonic acid is Lime-Water - I therefore pour some of this into this tumbler in which some of the carburetted hydrogen has been burnt - you see a precipitation is immediately formed. Carburetted Hydrogen gas is heavier than hydrogen - in as much as carbon which is heavier than hydrogen is added to it - It will therefore not answer for the purpose of balloons - It contains about 7/6 parts of carbon to one part & a third of hydrogen. -

—— In the year 1736 Lord Lowther who owned the coal mines at White Haven - collected some of the fire damp from the mine - & conveyed it to London, where it was burnt & occasioned, at that time, no sensation - It is only within the last 15 or 20 years, that this property of carburetted hydrogen has been applied to useful purposes.

It was first attempted in France. In the year 1798
Mr in this country, projected the idea of illu-
minating light-houses, by means of this gas. He received
some encouragement - but from some circumstance he
failed. Some years after this the gas was procured from
coal - Mr Murdock was the first who employed this in
England & so far succeeded that an extensive cotton Ma-
nufactory at Manchester was lighted by it. Soon after
this a patent was granted to Mr Winzor - a company
was formed under his direction, much money was raised,
but it was expended in preparatory experiments. Several
companies were however organized, with better success.
Three of these were in London - They have now laid
down in the Streets of that city 50 miles of pipe, by
which not only the city - but private Houses Manufac-
tories &c are lighted - I do not know how many Meters
they have - I believe five: The gas is contained in recei-
-vers made with Sheet iron, coated on the inside with char-
-coal & painted: They contain about 10.000 cubic ft
of gas. Although this gas for the purpose of lighting hou

-dings is usually procured from pitch, yet I am persuaded from what I have read & from my own experiments & observations that if a city is to be lighted with gas it must be procured from charcoal. The reason of this is, that it is much more economical; if pitch or any substance is used the residuum is useless but the residuum from coal is very valuable. The coke sells at a high price, & independant of this the tar & hartshorne collected will contribute very much to pay for the coal employed. In this country, the gas has been conveniently procured from wood. Dr Ziegler of this city was the first who employed pitch

—— Hydrogen gas in the second place unites chemically with Phosphorus forming the Phosphorated Hydrogen Gas. This is procured by placing in a retort a strong solution of Potash & a quantity of phosphorus. The water is decomposed its oxygen unites with part of the phosphorus, forming phosphoric acid, which dissolves the potash thus producing phosphate of potash. The hydrogen of the water unites with another portion of phosphorus & is evolved in the form of phosphorated hy-

-drogen gas. The peculiar property of this gas is, that it fires when it comes into contact with the atmospheric air, at ordi-nary temperatures. Cold water, often contains a quanti-ty of air, & on this account should not be employed in collecting & keeping this gas - violent explosions have resulted from neglecting this circumstance. When heat is applied to a retort containing the above-mentioned materials, the gas at first comes over freely - but sometimes no gas is evolved - a vacuum is formed - & the water rushes into the retort - An explosion usually results in such cases, un-less the water be very warm - . — When Phosp.d Hydro-gen gas is burnt in oxygen gas - the combustion is very brilliant. Phosphoric acid & water are formed - which produces a vacuum & the water rises. That this gas is really a com-bination of Phosphorus & Hydrogen is proved by this - That if Phosphorus alone came over - it would fall to the bot-tom of the vessel - - That if water or either of its constitu-ent parts came over - it would not inflame - The only con-clusion that can be drawn is, that the hydrogen of the wa-

ter unites with the phosphorus & forms the gas in question. I have in this phial a quantity of Phosphorated Hydrogen gas. I throw up some oxygen gas - & you see what a vivid light is produced. This serves to show that combustion is the union of oxygen with any substance, capable of being burnt. In this gas the phosphorus is in superabundance & therefore when the gas is burnt, a brown deposit is evident on the sides of the vessel - this substance is the phosphorus which was in excess.

Phosphorus is procured from animals usually from the bones of animals. Bones in general - more particularly human bones consist of phosphoric acid in union with lime. There is no proof, that phosphoric acid is procured from any food which we eat - this may be the case - but it is not proved. It is almost certain that it is formed in the body during its healthy state & superabundantly in disease. We cannot absolutely deny that this acid is in our food, in as much as we cannot by direct experiment, determine this question - but it appears so universally, so regularly - & so constantly, that we

must conclude, that it is a product of the animal economy, that it is a secretion peculiar to the living body. It is often in excess in some diseases - in others there is a deficiency as in rickets. — That bones consist chiefly of the phosphate of lime, we know because the acid can be procured from bones. Let a quantity of bones be burnt to remove the carbon the oily matters &c - & then be finely powdered - To one hundred parts of this powder by weight add forty parts of sulphuric acid - let the mixture be stirred & stand for a few days. The oil of vitriol unites with the lime forming gypsum or plaster of Paris: the phosphoric acid, being now free, can be washed away. When from this acid we abstract oxygen by means of charcoal - & distil in a retort - some phosphorated hydrogen - carbonated hydrogen & carbonic acid gases are dispersed - after which the phosphorus comes over & drops into the water — The usual method of forming into sticks, as we receive it - is, to strain it thro' cambric into cylindrical moulds. In warm weather - & indeed at all times - it is dangerous to handle

phosphorus - as it inflames at common temperatures - & during combustion forms a powerful acid - rendering the burn very severe. It is proper also to remember that it inflames more readily upon being pressed, it should therefore always be broken under water. Phosphorus has been used in making matches - but they are but little employed; as the bottle must be so often opened - that in a short time by the admission of air, the phosphorus is converted into phosphoric acid. The best matches are those which are made with phosphorus & come to us in glass tubes hermetically sealed: they are very expensive. Phosphorus has been used in medicine. Under the form of phosphate of soda - it is an agreable purgative. In substance it has been used in France, as a violent tonic, but so many precautions are requisite, that it has not been generally employed.

Hydrogen gas unites chemically with Sulphur & forms the Sulphurated Hydrogen Gas. This is the gas which impregnates many of the springs - which are the fashionable resorts ~~of~~ in England & in this country. There is one at Harrow-Gate in Eng^d - there is one in

~~in~~ the country about 5 miles from Carlisle - another at York - known by the name of the York Springs - there is one also in Virg^a: in fact they are common in lime stone countries - Wherever iron & sulphur meet - they decompose water - the hydrogen of the water unites with the sulphur & forms sulphurated hydrogen gas: if this cannot escape it becomes absorbed by any spring, forming the celebrated sulphur springs. These are well known by their offensive smell, which exactly resembles that of putrid eggs. Whatever is very nasty, is by the vulgar considered as excellent physick; on this account the sulphur springs have been in high reputte, but as I believe, very undeservedly. The pure sulphur is, in every respect, much to be preferred. The sulphur springs usually contain ½ their volume of this gas; the way of ascertaining its presence is by the smell - by evaporating it - & by immersing in the fluid a piece of silver - which is immediately blackened. —— The sulphurated hydrogen gas is procured, by adding diluted sulphuric acid - to the sulphuret

of iron. The hydrogen of the water unites with the sulphur & forms the sulphurated hydrogen. The sulphuret of iron is made by heating the iron to a white heat & then rubbing it on sulphur. In this gas the sulphur is dissolved in the hydrogen, therefore when it is burnt the sulphur is deposited on the sides of the vessel. If it remains over water for a short time it is absorbed. this is more rapidly effected by shaking the gas with a portion of water. Thus if a phial be partially filled with water, & the remaining space be occupied with sulphurated hydrogen gas, let the hand be placed over the orifice while they are shaken together, it will be found that the hand will be pressed down with considerable force, on account of the absorption of the gas.

There is another gas formed by the combination of hydrogen with arsenic. It is prepared by adding arsenic to the mixture of iron filings & dilluted sulphuric acid; the hydrogen of the water dissolves the arsenic. But as this gas is of no use, as the experiments are unpleasant & as you can understand the theory from what has already been said on former gases. I will not detain you with

I proceed now to another class of substances, as I have sufficiently illustrated the natural & chemical histories of the Atmospheric air & Water - as well as of their constituent principles. I am now to say something of the Nitric Acid, of the gases formed from it & of its basis. — This is connected with the subjects of which I have been hitherto speaking. Atmospheric air has been said to consist of 4 parts of a gas which will neither support animal life or combustion to under it capable of answering these views our Creator has combined with it another gas oxygen - so that common air consists of 80 parts of nitrogen & 20 parts oxygen. Now, if instead of these proportions we should have 33 1/3 parts of oxygen & 66 2/3 parts of nitrogen a gas will be formed different from atmospheric air which is called Nitrous gas or Nitrous oxide — If they unite in the proportion of 66 2/3 parts oxygen to 33 1/3 parts nitrogen Nitrous Acid is formed. If the proportions be again altered so as to have 66 2/3 oxygen & 33 1/3 nitrogen We will have the

Nitric Acid: so that the only difference between the air you are breathing & the Aqua fortis on my table, arises merely from the different proportions of oxygen & nitrogen in their composition. As the Nitric Acid possesses so much oxygen - it easily parts with it to other substances, if therefore we wish to convert sugar into an acid, we boil it with Nitric acid - or also of Gum Arabic - &c &c -

We know, that sulphur burnt in the air forms an Acid, the oxygen at the same time disappearing - Yet is found, that the increase of the weight of the sulphur is exactly equal to the weight of the oxygen removed; the conclusion then is that the sulphur is converted into an acid by uniting with oxygen. We also know, that if Nitric Acid be boiled over Sulphur - an acid will be formed of a certain definite strength - therefore we know what the sulphur has gained & what the acid has lost, & in this way we ascertain that Aq. Fortis consists of 5/7 oxygen & 2/7 nitrogen.

Having stated so much as preliminary I shall now give you the History of this Acid & how it is made -

Nitric Acid is procured from Nitre or Salt Petre. by adding 2 parts by weight of oil of Vitriol to 3 parts

of Nitre. It comes over in the form of red fumes, which attracts oxygen from the Atmosphere - becoming stronger - this is the smoking &c. of Nitric Acid. The same process is pursued in obtaining it in a large way. Iron retorts are then generally used. — In various parts of the earth where there is what geologists have called the second series of lime stone, there are found caverns or cavities - in many of which the ground is impregnated with salt petre - having lime for its basis. The cause of this is not known; if I were to offer a conjecture - it would be, that it arises, in part at least, from being the retreats of animals for many years.

Nitre is found in Kentucky - in the bason of the Mississippi - & in all countries where there are lime beds - or strata preserving nearly a horizontal direction - having very little declivity - It is found generally on the Western side of the Alleghany Mountains - also in Spain - more abundantly in the East Indies - which is very excellent. In all these, lime is the basis - it is a Nitrate of Lime. For the purpose of forming the Nitrate of Potash - you add the

nitrate of lime to a ley of wood ashes the acid in this case unites with the potash of the ley. In France Nitre has been manufactured during the last few years. Being deprived of their commerce & feeling the want of this article not only in their culinary processes, but also in the manufacture of Gun Powder, the French had to resort to their Chemists. & they are indebted to their Scientific Chemists alone for all the advantages arising from the consumption of this article. All animal substances contain much nitrogen, vegetable substances very little. Wherever animal matter is putrefying, nitrogen is evolved which uniting with the oxygen of the atmosphere forms nitric acid. While nitrogen is developing & this acid is forming if there is present any alkali or earth a union will be effected. Thus in visiting old stables an efflorescence may often be seen on the walls. This is nitre formed during the gradual decomposition of animal matter. I remember to have seen this efflorescent appearance on the walls of a cellar in which salted meat had been kept for a long time. Mrs. Carter has known the French Chemists to formed

their beds for the production of Salt Petre - by stratifying refuse animal matter chiefly of the excrementitious kind with lime exposing the whole to the Atmosphere, but protecting it from rain, which would wash away the salt. At the expiration of 3 months the nitrate of lime thus formed was collected - & by being washed in lie - the common nitrate of potash was formed. Now that this salt is thus procured is evident from Exp^{t} - If Sulphuric acid be added to the Nitrate of Potash - it will unite with the potash & the nitric acid will be liberated. - If the red-fuming acid becomes white by mere exposure to oxygen - it is evident it may be owing to a union between them. And if from Nitric Acid I can take away any of the oxygen - it will be changed into the red-fuming acid. - No metal can be dissolved in an acid unless it is previously oxygenated. Thus if pure sulphuric acid be poured on iron, the iron will not be dissolved - but if water be added - the iron becomes oxygenated & is dissolved. If I therefore add some copper to the Nitric Acid - it will decompose the acid - attracting oxygen from it - & a gas will come over, which - if it

be immediately collected, is colorless & exhibits no acid properties. Let a piece of litmus paper be passed up into a jar of this gas - no change will be effected; if however atmospheric air be admitted, red fumes will appear & the litmus paper will become red, indicating acid properties. — The various strengths of Nitric Acid depend therefore on the proportion of oxygen. Hence if 2 measures of nitrous gas be mixed over water with one measure of oxygen gas, there will be a considerable rising of the water - owing to an acid having been formed which was absorbed by the water. In consequence of this property nitrous gas has been used to ascertain the purity of the atmosphere. For in proportion to the quantity of the Nitrous gas - & in proportion to the quantity of oxygen will be the absorption of the acid gas & the rise of the water. This is an Eudiometric experiment. There are many others, some of which I have already mentioned. The best & most convenient is the burning of phosphorus. But where the quantity of oxygen is to be accurately ascertained - we should repeat all the experiments & not trust entirely to one — —

There is another combination of oxygen & nitrogen of which I must say something. This is the Nitrous Oxide: it contains more oxygen than Atmospheric air, & less than the Nitrous Acid. As to the quantum of oxygen it is next to common air & possesses no acid properties. As it contains more oxygen than the Atmospheric air - it will support combustion more vividly & when breathed will be more stimulating. Chemists have ascertained that where there is no oxygen life will not continue; that quantity of this gas which exists in the Atmosphere is the best adapted to support life; when there is more oxygen - it acts as a stimulant & may be employed as a medicine. When this gas is breathed, it stimulates so as to produce intoxication - which is not similar to that produced by ardent Spirits but is pleasant & leaves no ill effects behind. The probable reason of this, is - that it is of the same nature, as the air we constantly breathe -

From this property of inducing intoxication, it has been much noticed not only by Chemists, but also by Physicians — Whether any especial benefit has yet been derived from respiring this or any other gas I do not know —

The only important properties of this gaseous oxide of Azote or Nitrogen, are that it supports combustion more vividly & affords a stronger stimulus to the body than atmospheric air. — It is an artificial gas & can be prepared by adding oxygen in due proportion to common air — or by taking away oxygen from the Nitrous or Nitric Acids. This last can be effected by adding metals to these Acids. Some metals will absorb more oxygen others less — If Tin be added to Nitric acid it will take away just so much oxygen as to convert the acid into Nitrous oxide. But Chemists always resort to the easiest & cheapest methods of obtaining the articles they wish; they are therefore in the habit of procuring this gas from the Nitrate of Ammonia: the acid thus combined can be decomposed by heat alone,

When this salt is subjected to the heat of a lamp, a portion of the oxygen of the Acid escapes & the Nitrous acide comes over. This gas contains 33⅓ of oxygen & 66⅔ of Nitrogen — It is not so easily decompond as the acids as it is a general rule in Chemistry, that, the larger the proportion is in which one substance unites with another, the more easily is it separated. Thus oxygen can be obtained with much more facility from Nitric Acid than it can from Atmospheric Air.

This finishes what I have to say on the Compounds of Oxygen & Nitrogen Gases — The next class to which I proceed is that which is formed from the muriatic acid in its various combinations. I shall notice the salt from which this acid is procured — the acid itself — & the Gases which are formed from it.

Common Salt is the substance from which the muriatic Acid is procured — The combinations of this acid are called Muriates agreably to the present Nomenclature.

I shall offer now some preliminary observations on the Natural & Artificial Histories of Com^n Salt.

This substance is found naturally, dissolved in the waters of the Ocean - & solid in the earth. I have mentioned on a former occasion that if you peal off the layers of an onion you have a good illustration of the strata or formations forming the crust of the earth - As yet we have not been able to penetrate more than 25 strata of the terraqueous onion - The lowest one which has not yet been overcome is the Granite - a stone found in the neighbourhood of this city - The next is the common building stone in this City - & so on - These are all regular - there are some exceptions to this arising from the various convulsions to which the earth has been subjected & mingling the different formations - but as a general rule it may be received - - After passing upwards from the granite - thro' 8 or 10 formations, we come to the red sand stone - next to which we find a layer of Gypsum or Plaster of Paris & salt - This varies from ¼ to one mile from the surface of the earth - It is much more superficial in some places, than in others. This arrangement pervades all this country - Not only here - but as

far as observations have been made - it prevails thro' the Globe. this has been more particularly shown in Europe & in this country. About 12 or 14 strata above that of the rock salt we come to a formation of coal - & above this there is usually another formation of gypsum & rock salt. In this country for want of perseverance & money we have never penetrated to the formation of salt - but merely to the springs which are impregnated with it. I have been in the Salt mines of Engd. - & found that the first salt met with - is impure & of a red dish colour from the admixture of the red stone above mentioned - after this they come to the pure white salt. This is dug up - brought to the surface - & is dissolved - so as more effectually to remove all impurities. When this solution is evaporated slowly large cubic crystals are obtained but if it is evaporated quickly at a boiling heat. the crystals are small, forming the basket salt.

Common salt is also found dissolved in the Waters of the Ocean - All rivers run in Ravines, which

are the drains by which the superfluous water is carried from the surface of the earth. The sea is the ravine of the whole earth. Its depth has been estimated at ¼ of a mile, but this is a mere vague conjecture. There are no facts upon which a conjecture can be founded. But to whatever depth it may go it must wash the edge of several formations & among others the edge of the formation of Rock Salt which I have fully noticed. This at once accounts for the saltness of the sea & to my mind is perfectly satisfactory. — I know only of one difference between the salt obtained from the sea & that from the mine. In the former that is always a little Epsom salt & generally some Glauber salt. These are not found in the latter salt or rock salt. In Warm Countries, where the temperature of the air is sufficient to evaporate the water little attention is paid to it ~~made~~ the evaporation being conducted very slowly & as there is full room the crystals are formed very large. Hence you see how large the Turks Island salt. The ~~Ice~~ Cubes of salt &c are. How well formed the crystals are. The Mother water always contains

Magnesia - In Eng[d] this is again evaporated & the salts obtained in Crystals.

Common Salt is composed of muriatic Acid & an alkali Soda - of this last more will be said hereafter - To seperate the muriatic acid from this combination, it is necessary that another acid should be added whose affinity to the Soda is greater than that of the muriatic acid. Such an one is found in the oil of vitriol or Sulphuric Acid - When this is added to the salt the muriatic acid is evolved in the form of gas - This is condensable by water as you have seen the nitrous acid - To obtain it in the form of gas it must therefore be collected over mercury or some other fluid which will not condense it. This gas possesses acid properties - If a piece of litmus paper be immersed in it, its colour will be changed to the red. - It is absorbable by water: If a piece of ice be sent up into a jar filled over mercury, the ice will be melted & the gas will disappear - So that considerable heat is also given out.

The smell of this gas is very disagreable & peculiar so as to alway indicate its presence when in a gaseous form. It will combine with the alkalies. Ammonia is procured from sal ammoniac or the muri: ammon: which is obtained directly or indirectly from animal substances - Ammonia exists as a gas - It is a compound of Hydrogen & Nitrogen. This gas I shall procure by adding quicklime to sal ammoniac. If the disengagement of this gas takes place in a close vessel filled with muriatick acid gas the sides of the vessel will be covered with a solid substance. This is the muriate of ammonia. a salt formed from two gases. — As the odour of this gas is very disagreable. I shall not detain you with making experiments. The same observation I would also apply to another gas, which I now exhibit to you. You may see that it has a slight tinge of green - from which circumstance it has been named Chlorine from the Greek Chloros or Green. I know of no other gas which possesses this colour. Manganese is a black

mineral substance much used by Glass makers & by Potters. It is an earthy heavy, black, mineral. The ore of a semimetal, common in Engd but more scarce in this country. It is employed by Chemists to procure oxygen gas. & is supposed to yield a purer gas than Nitre but from experiment I believe that the gas is procured more economically from Nitre & fully as pure as from Manganese: this substance however yields it very abundantly. Now when muriatic acid gas is distilled over manganese, a gas is produced which is this Chlorine or oxymuriatic acid. It has an unpleasant smell, is deleterious to animal life but is important in the Arts.

When muriatic acid is distilled over the black oxide of manganese, one of two circumstances takes place: either hydrogen is taken from the muriatic acid, or oxygen is added to it. Which of these actually occurs is yet undecided; it is a chemical dispute which has been much agitated for the last 10 yrs. I know of no experiment that

is free from objections - I do not attempt to decide, whether the old opinion that oxygen is added to the acid - or the modern one that hydrogen is taken from it is correct. At any rate I shall adhere to the old one, till an experiment shall be advanced which is decisive on the subject. On one side it is argued that as manganese yields oxygen very easily, & as the oxygen actually disappears from the manganese, & as the muriatic acid acquires those properties which oxygen in other cases communicates - we may with good reason conclude that oxygen is united to the acid. On the other side - as oxygen has never been clearly demonstrated in chlorine - as the phenomena can be readily explained without supposing that it is present - & as the muriatic acid can be reformed by adding hydrogen to chlorine we might suppose that the gas was produced from the muriatic by separating its hydrogen - Both of these theories have been predicated on numerous, well conducted experiments, executed by the most skilful & scientific Chemists of Europe - but the question is still undecided. —— Chlorine is heavier

than atmospheric air; it is absorbable by water - if in a confined vessel a portion of this gas be agitated with water - upon opening the vessel under water the quantity of gas absorbed will be evident by the rise of the water. It does not support combustion perfectly - it will support the burning of a coal - but not a flame - thus a candle would be extinguished by it - while ignited charcoal would continue to burn - It destroys all vegetable colours - but it does not turn the litmus paper to a decided red colour but takes away all colour. I have often observed that no acid will dissolve a metal unless the metal is previously oxidated, the common red lead is an oxide of that metal, containing about 1/4 pr Ct of oxygen - It is prepared by exposing the lead to a great heat in contact with the air. From this substance oxygen can be obtained partly by heat & partly by other methods - Thus if I add to it muriatic acid, I shall obtain the chlorine gas - In the gas thus obtained I immerse a piece of blue calico & a piece of green - the blue is almost instantly whitened

V the green is also changed in a short time - The blue colour of calico is given to it by the indigo which is employed in its manufacture; indigo is a vegetable blue which is not acted on as other vegetable blues by acid if it is immersed in muriatic acid it will not be changed - you see however that its colour is destroyed by the gas we are considering. Scheele Sheild - to whom Chemistry is more indebted than to any one who preceded him & indeed than to any who has since appeared first discovered this gas. In burning his experi[ments] he detected its property of destroying colours. Berthollet the elder was the first who employed it in bleaching - In 1789 or '90 it was introduced into the manufacturing establishments at Manchester in England - Since that period it has been much employed - Its value is increased by confining it to the latter stage of the process of bleaching - In this way a much greater degree of whiteness is communicated to goods, which can now be brought to market at a much shorter period than formerly. I do not go beyond bounds in asserting that this discovery of Scheele Sheild's is equal to the loan of

one millian of money to the inhabitants of Manchester.
In this country it has been supposed to supercede all other methods of bleaching, but this is not the case - it is only an auxillary which is employed in the latter stages of the process. If manufactures are ever carried to a great extent in this country much attention must be paid to the effects of this gas ——————

I now am to say something of Sulphur, of the acids of which it is the base & of the gases formed from them - Sulphur is a substance found in all Volcanic Countries; Europe & this country also are supplied from the neighbourhood of Mount Vesuvius. I do not know precisely from what formation it is eliminated - probably not from 10 or 12 lowest strata which are termed the "primitive" formations - but it appears to exist in some of the "secondary" strata. There are not sufficient facts to establish this point - & I therefore speak with hesitation. If this be the case it shows that Volcanoes merely affect the secondary strata. Sulphur is found pure

in a sublimed state - It may be sublimed from iron pyrites, which is a mineral substance usually found in coal countries in strata above the coal. At any rate wherever iron, sulphur & water meet together much heat will be generated: this can be shown artificially - if 50 lbs of sulphur be mixed with 50 lbs. of iron - & be moistened with water - & then be buried in the earth - a sufficient quantity of heat will be generated to evolve smoke & flame - Sulphur is not only found naturally uncombined but also combined with lime - This is particularly the case in the Genesee country - where there are a number of sulphur springs - which hold in solution the sulphuret of lime. These springs are numerous - when they first issue from the ground they are clear & transparent - but upon exposure to the air the sulphur is precipitated - forming a yellow margin to the stream - In the Arts only, the sublimed sulphur is employed - this is often found in veins & fissures in the earth - where there are mineral substances. How it is formed there is a mat-

-ter of Speculation. Some have supposed, that it is sub-
-limed from the parts below - others that it arises from de-
compositions going on above - facts are still wanting to
decide the point. In the year 1792 Mr Henry son of
Mr Henry the Chemist obtained Sulphur by roasting the
ore of copper as found in the island of Anglesea which is a
sulphuret of copper. He collected the Sulphur, that was
sublimed by this process & proposed its use in the Arts,
but it was found to contain arsenic. It was therefore given
up. I do not know that for the purpose of manufac-
tures - sulphur is procured any where else, than in the neigh-
bourhood of Volcanoes. — Sulphur is employed
chiefly in ~~the~~ making Sulphuric acid & Gun Powder:
It is used in small quantities in bleaching woollen goods,
these are subjected to the fumes of burning sulphur, which
form the Sulphurous acid. The great use of Sulphur
is in making the oil of vitriol. This acid was so named
as it was formerly obtained by distillation from ~~a~~ calcined
~~an~~ of green vitriol or Sulphate of iron - This process

X Not alone at any time, as sulphuric
acid would not be produced

was carried on in Iron Retorts. It was afterwards found out that sulphuric acid had very little action on lead- the acid was then made by burning sulphur in leaden chambers - but the supply of oxygen in this way was not sufficient & the process was very tardy. That the supply of oxygen might be more abundant - the sulphur was mixed with nitre In Europe the combustion is carried on in chambers lined with sheet lead - they are from 20 to 40 ft in length - 20 ft broad - & about 15 ft in height. About 3 inches of water covers the floor - on little frames or waggons made of lead - & having leaden wheels - is placed a mixture of 8 parts of Sulphur & one of Nitre well ground together. This is fired by a red hot iron - & the waggons rolled into the room - & the apertures are closed

By the burning of the sulphur in the air - sulphureous acid is obtained - This in conjunction with the heat decomposes the Nitre - & forms 2 products - the oxygen evolved unites with the acid & forms sulphuric acid, in the next place nitrous gas is formed which gives

-ant its oxygen to the sulphureous acid - which is thus converted into sulphuric acid & absorbed by the water below. This process is repeated several times, until the liquor is sufficiently strong. It is then drawn off into leaden pans which are placed in a sand bath & the superfluous water evaporated. The heat cannot be carried sufficiently far for this purpose - as the lead would be melted; to complete the process - the fluid is conveyed into glass retorts & then strongly heated. When sufficiently - it is about the specific gravity of 1.85 in France & in Eng^{d} 1 pt weighs $\frac{3}{4}$ 29 $\frac{1}{2}$ - which makes it about 1.85. When of this strength it is saleable; as it is then sufficiently strong for the purposes of the artist, as, for instance, to dissolve the Indigo in forming the Saxon blue - the proper proportions are $\frac{3}{4}$ 1 of the indigo to $\frac{3}{4}$ vij. of the acid. The use of the Sulphuric acid is to obtain the Spt of salt - from the muriate of Soda - to obtain Aqua Fortis from Nitre & also in the process of bleaching in which great quan-

tities are consumed. In Engd a prodigious quantity is applied to another purpose to which it is not in this country - I allude to the felting of Hats. Some sour is always employed by the Hatters - in Engd they use the Sulphuric Acid. In France & Germany they employ another method which is by means of a dilute solution of mercury in Nitric Acid - What is the theory of this or what advantage is derived from it I do not know. Another use to which Sulphur is applied is in the making of Gun Powder - This I believe, was first known to the Chinese & probably also to the inhabitants of the East Indies. The first notice of it is by Sir Roger Bacon - commonly named Friar Bacon - but the introduction of Gun powder as a means of war-fare is usually attributed to a German by the name of Swhartz. Gun-Powder is made by grinding together with great dexterity & accuracy - nitre, sulphur & charcoal. The charcoal should be pure - made from light wood - dry & as fresh as possible - the sulphur should be pure - as also the Nitre - This last is of so much importance that Government both here & in Engd have taken this into their own

hands. Nitre, you may remember is generally obtained in the form of K Nt. of Lime & in most cases contains a portion of common salt. This salt is deliquescent & gunpowder made with nitre which contains it will speedily spoil. It may be separated by boiling a solution of the nitre & crystallizing it - the crystals of common salt will first appear & may be removed: or it may be separated by washing the nitre, the muriate of soda being more soluble will be dissolved & carried off — The usual proportion of nitre in gunpowder is from 74 to 76 per Ct the quantity of charcoal & sulphur varies very much but is generally between 9 & 13 per Ct. So much does not depend on the proportion of the several ingredients as that they should be accurately & well mixed. Here is some powder which was in a few minutes to-day & is consequently not good. I will inflame it - you may see the white spots which are left behind - These are formed by the undecomposed nitre - ~~dust~~ when the gunpowder is good there is nothing whatever left, no black or white spots, the whole disappears. - While upon this subject, it will be con-

-venient to notice after detonating mixtures.

The Oxy-muriate of Potash is a compound of Potash & chlorine or oxy-muriatic acid: it contains much more oxygen than the combination of muriatic acid & Potash: this is one reason for supposing, that chlorine contains oxygen — As the ox. mur. potash contains more oxygen than nitre attempts have been made to substitute it in the making of gunpowder — one or two fatal accidents have caused this to be given up. As acids are formed by the combustion of gunpowder you find that the touch hole of guns is often very much enlarged. To prevent this it is now customary to make the touch hole of gold or platina. Platina is not acted on by the acids — but it is by the alkalies — on this account Gold is preferable for the above mentioned purpose. In consequence of the oxygen in the oxy-mur-pot: the heat evolved by its decomposition is very great. This salt can be decomposed by any acid having a stronger affinity for the potash, than the oxy-mur: has. Sulphuric acid is one of these. When added to the salt — it forms the acid Sulphate of Potash & the oxygen

gas meeting any combustible body immediately inflames it. Thus if a match be dipped in sulphur & have its extremity tipped with a mixture of oxy-mur: of Pot: & Sugar it will be inflamed by dipping it with sulphuric acid. There are the common matches for lighting lamps. The effect is more beautifully seen by placing a little of this salt on a portion of Gun Powder. The whole will be inflamed by adding a drop of the acid. The inconvenience of using the above matches is that the acid is often converted into sulphureous acid by depriving the cork & it soon becomes weakened by the absorption from the atmosphere.

There are other explosive mixtures. There is one a preparation of Gold & is called fulminating gold. When Gold is precipitated from its solution in Aq: regia (which is the solvent of gold) it is a compound of the Nitric & muriatic acids by means of the Sp: Hartshorn. a powder is obtained which detonates violently when exposed to heat.

Fulminating Mercury is prepared by precipitating Mercury from its solution in Nitric Acid by means of the Spirit of Wine. A portion struck by a hammer on

an anvil will detonate violently.

When silver is precipitated from its solution in Nitric acid - by Spirit of Wine - a white precipitate is obtained, called fulminating silver - which detonates when exposed to flame Another of these detonating mixtures is formed by combining oxy-muriat: pot: with sulphur & charcoal in small quantities. — — When I was a boy - I frequently made a powder of this explosive nature (by mixing together 5 parts of Nitre, one of pot ash & 2 of Sulphur: warming them & then grinding them well in a mortar —

I will not detain you any longer with these - for they have not been applied to any practical purposes - they are singular - & so far advantageous as exhibiting the effects produced by Chemical Affinity.

The gaseous products of Sulphur must claim our attention - When sulphur is united with so much oxygen as to constitute the first state of oxygenation, it forms the Sulphurous Acid. The termination - ous in this & other acids indicates, that the combination of oxygen is less than the point of saturation; when it terminates in ic as Sulphuric - it indicates that the base

is completely saturated with oxygen - In the sulphurous acid the oxygen is in a certain definite proportion - but is not in sufficient quantity to saturate the sulphur - This acid is volatile - it can exist in a gaseous form - The sulphuric acid cannot exist in this form it is not volatile - uniting readily with water & falling to the bottom of the leaden chambers in which it is manufactured. The sulphureous acid is made from the sulphuric - by abstracting oxygen - This is done by dissolving mercury in oil of vitriol - any metal will answer - if it is soluble in pure oil of vitriol - now iron is not - the acid must be diluted with water, in which case the water instead of the acid is decomposed & hydrogen gas instead of sulphureous acid is evolved. When mercury is dissolved in sulphuric acid - which contains 40 parts by weight of sulphur & 60 parts of oxygen - it first abstracts a portion of oxygen from the acid - by which the oil of vitriol is converted into sulphureous acid which is then evolved in a

gaseous form: for no metal is soluble in an acid, till it is previously oxidated. — There are other methods of obtaining this acid. Burn sulphur under a bell glass inverted over mercury — during the combustion the sulphur unites with the oxygen of the air, & is converted into sulphurous acid, which will be found in the receiver. —— If you distil charcoal moistened with sulphuric Acid, the acid will be decomposed — the charcoal will unite with part of its oxygen & form carbonic Acid & sulphureous acid will be produced. — If sulphur be heated with the metallic oxides, the oxides will be decomposed — their oxygen will unite with the sulphur forming the acid in question & the metals will appear in their pure state —

This Gas is about twice as heavy as atmospheric air 100 cubic inches weighing nearly 70 grs. It extinguishes flame & light — as all other acids & will not therefore support animal life — When united with ammoniacal gas, it forms a solid. The Ammoniacal gas is formed by decomposing sal ammoniac by quick

-lime - the acid unites with the ammonia in this gas & forms the solid Sulphite of Ammonia. —— If sulphureous acid gas be passed over ignited charcoal, it is decomposed - its oxygen unites with the carbon & forms carbonic acid - & the Sulphur reappears in substance. - This gas is absorbed by Water: it is converted into Sulphuric Acid by adding oxygen to it: it consists of nearly equal parts by wright of sulphur & oxygen. It is the gas first formed in the manufacture of the Sulphuric Acid. When any combustible substance is dropt into oil of vitriol it will be partially burnt & the acid be partially decomposed sulphurous acid will in part be formed - & the whole will be of a dark - blackish colour. The acid may be again formed by adding to it a portion of Nitre & gently heating it - The black colour will disappear & sulphuric acid be formed by means of the oxygen in the acid of the Nitre — This acid is used to bleach silks & woollens during the last stage of the process - These are not coloured by any vegetable substance but by an animal matter - All animal substance,

become yellow by the addition of one of the powerful acids, by which a quantity of oxygen is given out. Thus Nitric acid will turn the skin to a yellow colour. So by it the common quills are clarified. In using this acid in bleaching silks &c the articles are hung up in a room & sulphur is slowly burnt in it. Sulphurous acid is formed which renders them of a beautiful white colour. I do not know that it is used in the Arts, for any other purposes: it may be useful to know that by washing clothes for a long time in soap they acquire a yellow colour which may be obviated by employing the fumes from Sulphur, as above directed.

I am now to notice another Gas. About six years ago a French Manufacturer in making Soap discovered a peculiar violet coloured gas arising from his alkaline lie. This lie was usually procured from the alkali, named Soda. This alkali is found in all plants growing near the Sea but is more abundant in some than in others: as obtained from them it is also called barilla. Both Barilla is employed in the manufacture of hard soaps, as it possesses the property of giving out its water of

crystalization when exposed to the Atmosphere.
This substance is procured by decomposing the lye of barilla after all the alkali has been separated from it - by means of an acid - when heat is added to this substance - a beautiful violet coloured ~~substance~~ gas is formed - which is called the iodine gas - & the substance iodine - I did think when I first heard of this gas - that the soap boilers would use the imported barilla - which is the ashes of sea weed - comes to us in a black stony mass - & is usually known by the name of black ashes. These are ground finely & a lye is made from them - But in consequence of restrictions & interruption of commerce a manufacture has been made of artificial barilla - by decomposing the Glauber's salt - Now if the mother water of barilla only contains iodine, this artificial substance will not contain any of it - altho' it is known & sold by the same name as the former - The barilla used here in Eng^d is of this artificial kind - & I therefore could not make any of the iodine myself but was under the necessity of importing it from Europe - Sulphuric acid is usually employed in decomposing the mother water of barilla - sometimes it is ne-

cessary to add a little of the red oxide of lead or of the black oxide of manganese, that the requisite quantity of oxygen may be afforded for forming the iodic acid. The iodine is obtained in form of a black powder, which when gently heated is converted into the iodic gas. This last upon cooling again is condensed into the black powder, I do not know of any use to which this has been applied - it enters into many chemical combinations, which having as yet of no service I will pass by. —

Red-precipitate is an oxide of mercury - obtained by heating mercury to a great degree in contact with the atmosphere, or by decomposing nitric acid over mercury. If this red precipitate be boiled on prussian blue & the solution be filtered, evaporated & crystallized, a salt will be obtained - which when exposed to heat produces a gas, called cyanogen. The characteristic property of it is that it burns with a blue flame. As this gas has not hitherto been applied to any useful purpose I have nothing more to say about it: feeling however quite confident that at some future period its virtues & uses will be fully investigated.

The last gas to be considered is the Fluoric Acid gas. In Derbyshire & other parts of England, as also on the Continent a Spar is found, which was originally called the Derbyshire Spar. It was formerly much employed as an Ornament. The people of Derbyshire afterwards employed it in their fluxes for melting lead: hence it was called Fluor Spar. In Chemistry it is termed the Fluate of lime, as it is found to be a combination of a peculiar acid, called fluoric acid & lime. — Scheele was the first who investigated the nature of the Fluor Spar. In this country we have very little of it: I have seen some specimens procured in the U. States, but they are rare. In Derbyshire, it is found in the oldest limestones of the secondary class, about the red-sand stone formation. In analysing this substance Scheele added to it the Sulphuric acid. this united with the lime forming the Sulphate of lime, & a dense vapour

arone, which was found to be an acid & to possess peculiar properties. If kept in glass vessels, it was discovered that the glass will be corroded; this acid dissolves the silex in its composition: hence, we must procure it in leaden retorts & leaden receivers. This acid gas possesses only one characteristic property, which is that of dissolving flint or silex. From this property, it has been employed to etch on Glass. Engravers on Copper cover the plate with wax & on this draw the intended sketch - sulphuric acid being now poured on it, acts on the Copper where the wax is removed & thus, when the surface is cleaned, the lines will be found neatly traced. In the same manner Glass can be etched by this gas: the surface being covered with wax & the drawing made, the whole is to be exposed to the gas & in a short time the gas will be acted on - or be bitten (which is the technical phrase). The common method of engraving glass is by means of a brass or Copper wheel - the points of which - dipped with eme-

-ry, cut the glass as it is wished. This gas has no other Pe-
-culiar property- It is said, but it has not been sufficiently proved, That the fluoric acid is contained in the enamel of the Teeth: certain it is, that the enamel is very different from the bony part of the tooth, for if a tooth be boiled in a solution of Madder, the bony part will be coloured red while the enamel will be unaffected—

This finishes what I have to say, on the Pneumatic part of Chemistry: perhaps I have dwelt on the gases longer than I have given them a larger proportion of the course than may have been deemed proper; but as they are capable of being illustrated by more experiments- as they have a greater connection with the doctrines & theories of Chemists- & are of more practical importance, than any of the other divisions of our subject- I trust- your time has not been misspent- I now proceed to the Alkalies.

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Mr. Hugh Lenox Hodge